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CONTENTS

Vol. XXIII, Part II

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Original articles

REVIEWS

ORIGINAL ARTICLES

BIOLOGY AND CONTROL OF *DACUS DIVERSUS* COQUILLETT AND *CARPOMYIA VESUVIANA* COSTA AND IMPORTANT NOTES ON OTHER FRUIT FLIES IN INDIA

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(With Plates VI to VIII)

FRUIT flies are the important pests of several valuable crops all over the world. At the same time they are the difficult pests to control. Hence observations made on their biology and bionomics are likely to prove of value in the advancement of our knowledge in dealing with these obstinate pests. The common and more important species of fruit flies recorded in India are :

1. *Dacus diversus* Coquillett
2. *Carpomyia vesuviana* Costa
3. *D. ferrugineus* Fabricius
4. *D. zonatus* Saunders
5. *D. cucurbitae* Coquillett
6. *D. ciliatus ciliatus* (Loew)

In reviewing the work done so far on the above species it will be noted that the biology of *D. diversus* was practically unknown. In view of the importance of the species in the fields it was very necessary to know something about this pest. At the same time in view of the great damage done by *Carpomyia vesuviana* it was essential to study it in some greater detail.

The study of the biology of the pest is the first essential, but this alone does not solve our problem and we have to resort to the detailed study of bionomics or the field ecology of the pest. The importance of this study cannot be over emphasised, because it always leads to the practical solution of the baffling problem. This will be well grasped from the fact that we know a good deal about the melon fly, yet in Hawaii insecticidal methods of control failed to reduce its damage.

Thus Nishida and Bess [1950], studied the field ecology of the melon fly and concluded that majority of the gravid females visited the host plants for oviposition in the early forenoon and afternoon and nights are spent by them under the bushes along with the males and immature females. This though apparently an insignificant observation is very valuable one for an Economic Entomologist because the success of the control operations depends upon the correct timing and right selection of an insecticide for application against the pest. It is thus of great economic interest to record the movements and habits of the fruit flies in the field.

Dacus diversus Coquillett

Distribution

The fly has been recorded from Madras, Mysore, Bombay, Madhya Pradesh, Uttar Pradesh, W. Bengal, Assam, Delhi and the Punjab. Outside India it is present in Pakistan, Burma and Ceylon.

Food plants

Fletcher [1920] recorded guava (*Psidium guajava*), mango (*Mangifera indica*), *jamun* (*Eugenia jambolana*), sour orange (*Citrus aurantium*), bottle gourd (*Lagenaria vulgaris*), *Solanum verbaxcifolium*, *Cucurbita pepo*, radish and anthers of cucurbit flowers in India and mango and plantain (*Musa sapientum*) in Burma.

I may point out here that although various workers have recorded the above food plants as hosts of this species I failed to rear a single adult of *D. diversus* from any fruit, at any period, during the course of my investigations on fruit flies, for a pretty long period in the localities (Delhi and North West Frontier Province) where it was present in abundance. Where it breeds, had been the question before me and this had been weighing on my mind till August 1950 when in the course of my surveys for plant protection work I was successful in finding out that this is a species which according to my present finding breeds exclusively in the flowers of *Cucurbitaceous* plants. The record of its breeding in the above mentioned fruits may be due to (1) the absence or insufficiency of the favoured hosts or (2) change in the habits of the fly brought about by the seasonal variations of the particular locality.

Cucurbitaceous and other fruits are commonly grown throughout India and there can be no cause for insufficiency of food for the flies. The second seems to be a sound reason but this I hope will be substantiated by the workers from other parts of the country.

Amongst the *cucurbits* the flies have been reared from the flowers of white gourd (*Lagenaria vulgaris*), sponge gourd (*Luffa cylindrica*) and *Coccinia indica*. The first two are the most preferred hosts.

Nature and extent of damage

As the symptoms of attack of the fly were not prominently visible since long the exact nature and the amount of damage could not be ascertained. The puncture of the fly is faintly visible as a dark spot under the shiny brown resinous secretion on the unopened flower buds of cucurbits (Plate VI, Fig. 1a and 2a). The maggots feed inside the floral buds on the pollens and the convoluted anther tubes which are lacerated and badly riddled. In consequence the pollen tubes dry up. The maggots travel down and feed on the basal portion of anther and set in a slight amount of fermentation. The rotted mass can be spotted by the pale dark appearance of the calyx cup (Plate VI, Fig. 2b) from outside. An advanced rotting is observed only in half opened flowers of *Luffa cylindrica* (Plate VI, Fig. 1b) and sometimes a trickling syrupy juice usually associated with the damage of fruit flies may be visible, otherwise the floral buds are mostly damaged from within with the result that they begin to droop and ultimately die. In case of the bottle gourd the dried flower eventually falls off leaving the faded distal end of the flower stalk on the creeper (Plate VI, Fig. 2a to 2d). Mostly the male flowers are damaged. The female flowers are occasionally damaged but those that are damaged ultimately present charred petals and the faded distal end of the ovary (Plate VI, fig. 1c). When majority of the male flowers are damaged many of the tender fruits of cucurbits up for want of pollination.

Dacus diversus Coquillett

Fig. 1. *Luffa* flower shoot (natural size) : (1a) oviposition spot on flower bud, (1b) rooting flower bud, (1c) damaged ovary

Fig. 2. Bottle gourd flower bud (natural size) : (2a) oviposition spot, (2b) damaged bud with maggot inside, (2c) damaged flower, (2d) faded flower stalk

Fig. 3. An egg × 18

4

6

7

5

Dacus diversus Coquillett

Fig. 4. Full fed maggot × 9
Fig. 5. Pupa × 9
Fig. 6. Female fly × 9
Fig. 7. Male fly × 9

Description of various stages

Egg

The egg (Plate VI, Fig. 3) is shiny white, smooth, opaque, pointed at both ends and slightly curved. It measures 1·12 mm. long and 0·25 mm. broad.

Maggot

The full grown maggot (Plate VII, Fig. 4) is pale cream in colour, 12 segmented and cylindrical in shape. The dorsal vessel is prominent. It tapers anteriorly and is blunt at the hind end. The first segment or the head is slightly dark and bears black pharyngeal hooks. The segments 1 to five gradually increase in size, where as segments 6 to 11 are more or less of equal magnitude. The last segment is a little smaller than the preceding and ends in a depression dorsally to lodge the posterior stigmata. It measures 6·5 mm. × 1·00 mm.

Pupa

The pupa (Plate VII, Fig. 5) is barrel shaped, 11 segmented and measures 4·75 to 5·5 mm. in maximum length and 1·5 to 2·2 mm. in maximum breadth. The fourth segment is the largest while the following seven segments slightly narrow down posteriorly. Anteriorly the segments 3 to 1 gradually taper to form a dome shaped structure. It is light brown when freshly formed but becomes ochraceous after 4 to 5 days.

Adults

The adults are smoky or slaty dark brown in general body colour with lemon yellow markings on the thorax. The male (Plate VII, fig. 7) is smaller than the female and has suboviod abdomen. It measures 5·2 mm. long, 1·75 mm. broad and 10·5 mm. across the wings. The abdomen of the female is of the same shape, thick set and ends in a pointed ovipositor which is proportionately longer than that observed in the other *Dacus* species. The female fly (Plate VII, fig. 6) is 8·00 mm. long, 2·5 mm. broad and 12·5 mm. across the wings.

Life history

The adult flies are observed active on the flower buds of cucurbits during morning and evening hours both to feed and oviposit. They feed on the honey dew secreted by the aphids (*Aphis gossypii* Glover) present on the flower buds but are very often deterred by the presence of black ants (*Camponotus compressus* F.) which are also present on the buds for feeding on the honey dew of the aphids during the same time. The preoviposition period of the fly is about 18 days during August-September. The female fly quickly surveys the flower bud by moving up and down and constantly touching the surface of the fruit with the ovipositor and palpi with a view to select a suitable spot for oviposition. At the time of oviposition the fly bends its abdomen at right angle or makes an obtuse angle with the body and pierces the flower bud with its ovipositor to form a cavity in the corolla or the pollen tube to lodge an egg which is embedded vertically or obliquely less than a millimeter deep from the surface. As the eggs are not embedded deep hence only the distal part of the ovipositor is inserted. Having formed cavity within the bud, the fly

becomes motionless and releases the egg. In order to lay more eggs it takes a clockwise turn on its ovipositor as a pivot. Having completed half the circle it pauses for a while and reels back to the original spot in the same direction from which it had started. It takes out the ovipositor, releases shiny brown gummy secretion over the puncture, walks a small distance and stops a while to clean the ovipositor with its hind legs and flies away to another spot. The whole process of egg laying takes 2-3 minutes. The spot where eggs are laid is generally located in the middle of the bud at a place wherefrom the sepal diverge from the calyx cup or just below the tip of the sepal. If the interior is hard or unsuitable for the larval growth the fly leaves it as a pseudopuncture. Such a puncture is devoid of the gummy secretion. The precise role of the circular movement of the fly around its ovipositor as a pivot at the time of oviposition is yet not rightly understood but it seems the process provides more space for egg laying.

In captivity the flies laid eggs in floral buds of *Luffa* spp. but did not lay eggs in the fruits of mango, guava, *Luffa* spp. bitter gourd and *Coccinia indica*. Eggs were, however, laid in the tender fruit of brinjal. As the brinjal fruit was with the stalk and the calyx cup the fly considering it as a flower bud laid eggs in it piercing through the sepal. In all 11 eggs were laid, parallel and touching each other and vertically embedded. In fields the oviposition of the fly in brinjal fruits and the flowers is yet to be confirmed. The number of punctures on each bud varies from one to three. The maximum number of maggots in each bud counted is five and generally it varies from one to three. The incubation period of the egg ranges from 1-4 days in July.

The full grown maggot is active and can hop from a looped state to a distance of 3 to 6 in. long and 1 to 1·5 in. high. The larval stage lasts for four to five days in September. When the number of maggots is three or more in one bud, rotting sets in. Excess of moisture has been found detrimental to the growth of the maggots. In nature whenever there was greater rotting in the bud, maggots recovered had been dead. This is why the species has adapted to breed in the flower buds where the chances of excessive rotting are practically nil.

The full grown larva leaves the fruit to pupate 1 to 3 in. below the soil. In the laboratory the maggots pupated both in and outside the flower buds because the flower buds dried up soon and they were forced to pupate inside. The duration of the pupal stage is seven days in August and 13 days in November as shown below in Table I.

TABLE I

Duration of pupal stage

Date of pupation	Date of emergence	Number of pupal days
16-8-50	24-8-50	8
28-9-50	5/6-10-50	7-8
3-11-50	15/16-11-50	12-13
6-11-50	17/18-11-50	11-12
8-11-50	20-11-50	12

At the time of emergence of the fly from the pupa a cleft occurs latero-ventrally upto the middle of the fourth segment at the anterior end of the pupa. The dorsal portion remains intact. This gives enough space for the fly to gradually wriggle out with its folded wings. After emergence the fly sits stationary for about 2 to 3 hours at a secluded place to stretch its wings and develop normal colouration. An interesting feature observed in this species has been that the flies had emerged from pupa even in the afternoon whereas the emergence of the flies so far recorded from other *Dacus* species had always been in the forenoon. Mortality in the pupal stage was low. The laboratory bred pupae were slightly smaller owing to the fact that the flower buds could not be maintained in the proper condition. The flies reared were also small in size. The adult lived for 23 days (female) and 26 days (male) in September. In the cages they were fed on soaked raisin, mango pulp or cut *Luffa* fruit. It seems owing to unsuitability of weather in September the adults were short lived otherwise the adults are long lived and over winter as such.

Bionomics

The fly is active throughout the year. It breeds in cucurbit flower buds during summer months and on the approach of winter in November it migrates to fruit orchards where it overwinters in the adult stage. The flies subsist on the honey dew of the sucking insects found on fruit trees. After dusk they congregate under the leaves of mulberry, fig, guava, citrus and loquat and disperse during the day after search for food. In winter when there is sufficient cold and the leaves of deciduous fruit trees have fallen the flies are met under the folds of dried leaves of guava and loquat. In Delhi the adult flies have been observed congregating under the leaves of loquat in association with *D. cucurbitae* in the month of December. The population of *D. diversus* is in greater proportion to that of *D. cucurbitae*. In March-April when the temperature rises the flies begin to migrate from the fruit gardens to cucurbit fields to breed in the floral buds of their hosts. The male flies are attracted to the smell of citronella, iso-eugenol, clensel, papaya bloom and sour sop (*Anona muricata*). The female flies in their act of oviposition are greatly deterred by the black ants (*Camponotus compressus* F.) which thus save some buds from damage. Observations so far recorded tend to indicate that it is a hardy species and can stand the period of scarcity of food better than other *Dacus* species. Like *D. cucurbitae* it breeds well under optimum conditions of temperature and humidity and in years of less rainfall the degree of infestation observed has been low.

As already stated the maggots do not stand excessive juice and whenever there had been copious moisture as a result of greater rotting in the bud the maggots died. The quick death of its offspring in a greatly rotting fruit is perhaps the reason for the adaptation of this fly to restrict its breeding in the flower buds of cucurbits.

Carpomyia vesuviana Costa

The *ber* fruit fly, *Carpomyia vesuviana* Costa is the chief and widespread pest of *ber* (*Zizyphus jujuba*) throughout India. The damage done is not only extensive but it is also intensive in some years with the result that it is difficult to get a *ber*

fruit free of maggots and every year a large amount of valuable food of the masses is rendered unfit for human consumption in the country. In view of the great loss it was necessary to know in detail the life history of the pest and causes for its epidemic occurrence. The author took up the detailed study of the pest at the Indian Agricultural Research Institute at the suggestion of the Head of the Division of Entomology immediately after partition of the country. This study was necessary because firstly very little information was at hand about the pest. Excepting Khare [1923] who published preliminary observations on the life history of the pest the subject seemed to have been barely touched. Secondly it was high time to have a thorough knowledge of the pest with a view to devise effective control measures against the fly pest and thereby to save as much as possible the poor man's subsidiary and desert food in these days of shortage. Here in the following pages is described the biology, and the field ecology of the pest and suggestions for suitable measures to be taken against it as a result of the study made during 1948-52.

Distribution

The *ber* fruit fly is found everywhere in India where *ber* is grown. Its presence has been recorded in the Punjab, PEPSU, Delhi, Uttar Pradesh, Bihar, Orissa, Madhya Pradesh, Vindhya Pradesh, Madras and Bombay.

Outside India it is known to occur in W. Pakistan, Afghanistan, Ceylon, Burma, Mallaca, Malay Archipelago, Australia, Portici, Italy, China and South Europe.

Food plants

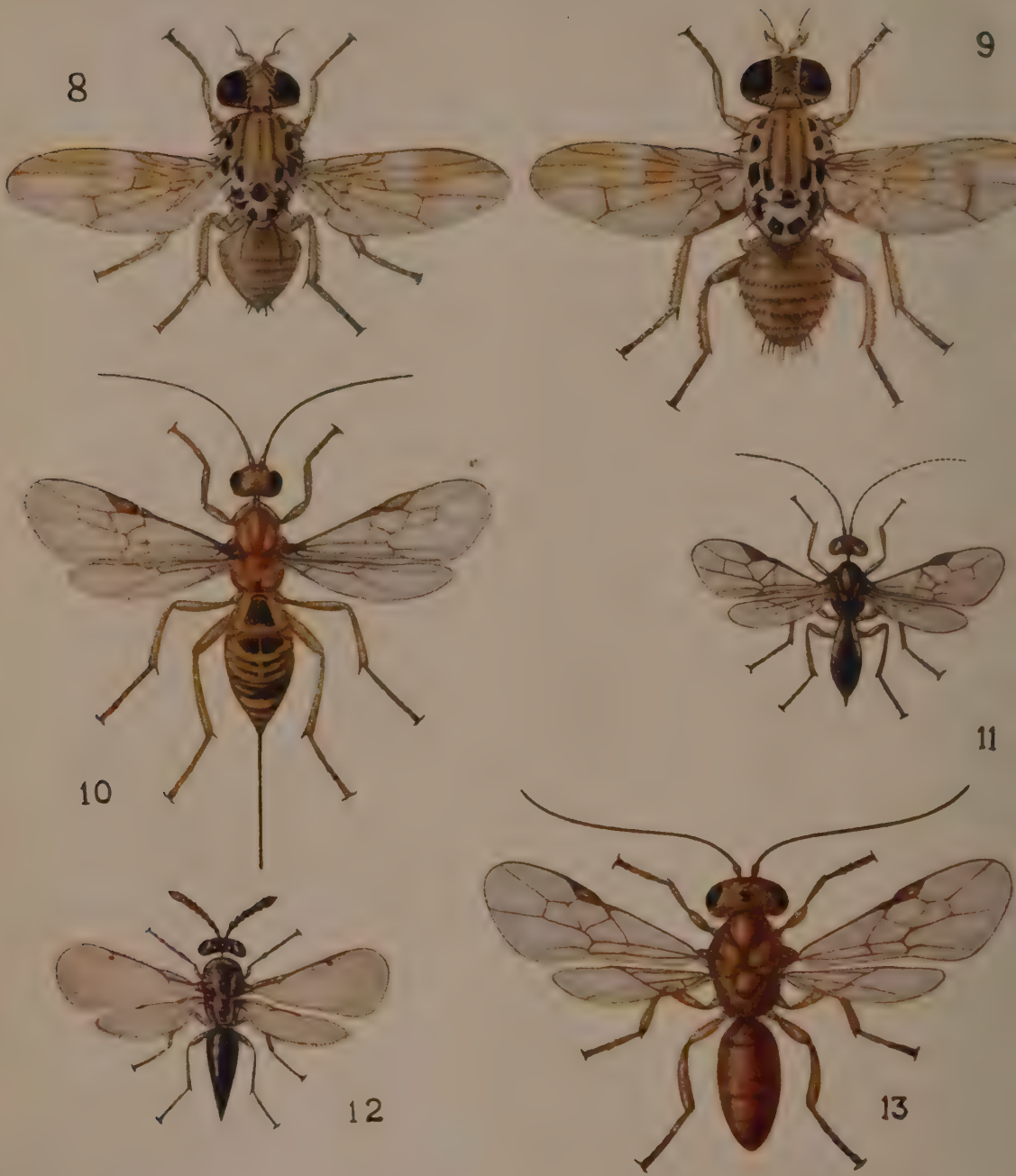
The pest is monophagous, i.e. only attacks *ber* plants in India. The fruits of cultivated *ber* (*Zizyphus jujuba*) and *ber* bushes (*Zizyphus nummularia*) growing wild on hillocks are attacked. In Italy the fruit of *Zizyphus sativa* is attacked.

Nature and extent of damage

The fly attacks the fruit as soon as it is formed. The grafted fruits are attacked when they are hardly 1·3 to 2 cm. long and 0·5 to 1·5 cm. broad. The fly inserts its ovipositor inside the rind of the fruit to form a cavity and hardens the surrounding tissue with a cementing fluid with the result that the unaffected areas grow out and the puncture is seen located in a depression. This uneven growth gives the attacked fruit (Plate VIII, fig. 3) a rugged appearance, which can be located from a distance. This sort of damage is caused to the fruit in winter when the fruit is in active growth. In spring only the dark puncture is faintly located and surface of the fruit is not distorted. Externally the puncture (Plate VIII, fig. 1) is bordered by slightly cretaceous or brownish minute particles and looks dark against the greenish or yellowish green background of the fruit. It is sometimes surrounded by a red circle and is slightly enlarged as a result of decay that sets in after the maggot has fed under the immediate vicinity of the rind. Usually the maggot as soon as it hatches, bores in towards the core and feeds on the pulp. When full-fed it leaves the fruit by cutting out a small circular hole. On cutting open an attacked fruit brownish coloured insect galleries lined with maggotty excreta (Plate VIII, fig. 2) are seen inside. A

Carpomyia vesuviana Costa

Fig. 1. *Ber* fruit showing oviposition punctures
Fig. 2. Damaged fruit with maggots
Fig. 3. Rugged fruit showing the exit hole of the maggot
Fig. 4. Exit hole of the parasite (Fig. 1-4, natural size)
Fig. 5. Egg × 30
Fig. 6. Full fed maggot × 9
Fig. 7. Pupa × 9



Carpomyia vesuviana Costa

Fig. 8. Female fly × 9
Fig. 9. Male fly × 9
Fig. 10, 11, 13 Braconid parasites × 9
Fig. 12. Chalcid parasite

single maggot is enough to render the fruit unfit for human consumption. During the peak period of attack the number of maggots is more than one inside the fruit and the whole pulp is consumed and decay set in by the maggots with the result that when damage has been completed, nothing but a semi-solid decayed dark brownish mass which smells offensively, is found within the fruit. The attacked fruit, unless fully ripe, does not fall but maggots leave it through a circular exit (Plate VIII, fig. 3). Owing to severity of attack not less than 80 per cent of the fruits are lost by this pest in some parts of the country.

Description of the various stages

Egg.—The egg (Plate VIII, fig. 5) is dull creamy white, opaque, slightly pointed towards the ends. It measures 0·91×0·28 mm.

Maggot.—The full grown maggot (Plate VIII, fig. 6) is amphineustic, cretaceous or creamy white pointed anteriorly and ends in a broad truncated last segment. The dorsal vessel is prominent. Dorsally the last segment has a depression to lodge the posterior stigmata which look like brownish approximated and prominent tubercles. The anterior spiracles are borne on the third segment. Segments 6 to 1 gradually taper anteriorly and 7 to 12 are of equal magnitude and contoured with fleshy points to help in locomotion. It is 6 mm. in maximum length and 1·50 mm. in maximum breadth.

Pupa.—Well developed pupa (Plate VIII, fig. 7) measures 4·25 to 4·75 mm. long and 1·80 to 2·0 mm. broad. It is opaque and barrel shaped. The first and last segments are smaller than the rest and bear spiracles. The segments on either end, i.e., both anteriorly and posteriorly slightly taper. It is however comparatively more pointed anteriorly. When freshly formed the pupa has a prominent dorsal vessel and is concolourous with the maggot. It turns light brown after 5 to 6 hours in April and 24 hours in December and assumes ochraceous colour after 3 to 4 days.

Adults.—The head of the freshly emerged adult is light almond brown. The thorax is light almond brown ventrally and deep almond brown dorsally. The eyes are shiny and with a greenish slaty hue. The abdomen is slightly pale both dorsally and ventrally. The wings are hyaline and transparent. After sometimes the normal colouration is developed (Plate VIII A, female fig. 8, male fig. 9). Bezzi [1903] has described it as under.

" A yellow black spotted species with four yellow cross bands on the wings very like *M. pardalina* Bigot but besides the generic characters distinguished by the two apical black spots of the scutellum. The fronto-orbital bristles yellowish and the vertical bristles yellow, occipital row well developed yellow. The thoracic bristles are yellowish at the end while the scutellar ones almost entirely yellow. The two scutellar black spots are separated by a narrow yellow line. "

Life history

Preoviposition.—The adult flies, unlike *Dacus* species, have been observed to mate for long period ranging from 2 to 10 hours at a stretch during the day time. In the act of copulation the female rests in its normal posture. The male approaches the female and holds its abdomen with the front pair of legs and rests on it and the support afforded by the second and third pair of its legs. Dorsally the frons of the male touches the posterior portion of the thorax of the female. The male slightly bends its abdomen and extends out its aedagus into the genital pore of the female. The aedagus is extensile by means of a prominent filament seen laterо-ventrally of the female abdomen at the time of copulation. It is why the male has not to bend its abdomen acutely for copulation. At the time of copulation the pair may be found sitting on the leaf or fruit. It aviods all disturbance and does not feed. In case of disturbance the pair swiftly walks or flies away to another safe spot without getting separated. Mating starts 4 to 13 days after emergence and is repeated frequently by the flies. In a typical case the pair coupled about a dozen times in captivity during the preoviposition and oviposition periods at intervals ranging from 24 hours to as long as 16 days.

Oviposition.—The female places its ovipositor on the skin of the fruit by bending the abdomen which forms more or less a right angle with the body and exerts pressure on it by the forward and backward movement of the body with the result that the ovipositor is thrust in. The interior is pierced several times to form a cavity. The egg is laid after making the tissues surrounding the cavity impervious with a gummy secretion. At the time of egg-laying the body of the female becomes motionless except the convulsive movement of the abdomen both forward and backward and accompanied by a wave of pulsating movement. This way the safe delivery of the egg is ensured. The egg is embedded upright or laid at an angle $\frac{1}{2}$ to $1\frac{1}{2}$ mm. deep from the rind depending upon the texture of the pulp. Not infrequently, only one egg is laid in each puncture. Very rarely two are found touching one another. The whole process of egg laying does not take more than five minutes. In selecting a spot for egg laying the fly always selects a lower or protected spot to evade disturbance at the time of oviposition. Eggs are laid any time during the day. The number of punctures on each fruit is one or occasionally two in the winter brood but as many as 11 have been counted on the surface of the fruit measuring 26 mm.$\times$11 mm. in the spring broad Pseudopunctures observed on the fruit were during the beginning or close of oviposition period. These are generally faintly visible and imperfectly covered with the protective material. The laboratory bred flies did not live to breed in captivity but only a single pair of the flies collected from the field successfully bred in the breeding cage, therefore, the number of eggs laid, the oviposition period and the longevity of the flies could be studied from one experiment only. The number of eggs and the interval at which they were laid are given in Table II.

TABLE II

The number of eggs and the interval at which they were laid by the female

Date	Number of eggs laid
18-3-49	6
19-3-49	2
20-3-49	6
21-3-49	2
22-3-49	5
24-3-49	1
25-3-49	7
26-3-49	2
27-3-49	3
30-3-49	4
31-3-49	2
1-4-49	3
3-4-49	3
7-4-49	1
15-4-49	2
TOTAL	49

A female thus laid 49 eggs in her life time and laid eggs almost daily or at short intervals excepting the last laying in which these were laid after an interval of 8 days. The duration of pre-oviposition, oviposition and post-oviposition periods was 16, 29 and 25 days respectively as indicated in Table III.

TABLE III

The duration of pre-oviposition, oviposition and post-oviposition

Period	Duration	Number of days	Remarks
Pre-oviposition	*2-3-49 to 17-3-49	16	*Female collected
Oviposition	18-3-49 to 15-4-49	29	
Post-oviposition	16-4-49 to †11-5-49	25	†Female died

Maggot. At the time of emergence of the maggot from an egg, anteriorly pulsating movement of the larva is observed. The larva forces its wayout by regular expansion and contraction movements of the body aided by the piercing act of its pharyngeal hooks causing a cleft at the micropylar end of the egg at its ventral aspect. The egg shell is left behind. Whenever the egg was exposed for observations it used to shrivel soon and die without hatching.

The incubation period of eggs varies from 1 to 4 days in March-April as detailed in Table IV.

TABLE IV

The incubation period of eggs

Eggs laid	Eggs hatched	Incubation days
20-3-49	24-3-49	4
21-3-49	25-3-49	4
24-3-49	28-3-49	4
26-3-49	30-3-49	4
27-3-49	30-3-49	3
7-4-49	9-4-49	1
15-4-49	16-4-49	1

The young maggot on hatching feeds on the pulp and it has been observed that the larval growth takes longer time in the laboratory than that in nature, because in nature the attacked fruit does not fall and both the egg and

larval stages are completed within the fruit which maintains its freshness in the tree, whereas, under laboratory conditions the fruits dried resulting in decrease in the moisture content and increase in the sugar content. Owing to the variation in the right proportion of moisture and sugar in food the duration of the larval stage and its instars was affected and it was observed to be longer than what it would have been in nature. The maggot moults two times in its life time as shown in Table V.

TABLE V

Moulting of maggot in its life-time

Stage	Date	Stage of instar	Duration in days
Hatching of egg	30-4-49	1st	2
1st moult	1-4-49	2nd	3
2nd moult	4-4-49	3rd	4
Pupation	8-4-49		

The larval period lasts 9 to 12 days in March and about 22 days in November-December as shown in Table VI.

TABLE VI

The duration of larval stage

Date of hatching	Date of pupation	Duration in days
29-3-49	7-4-49	9
30-3-49	8-4-49	9
30-3-49	11-4-49	12
13-11-49	5-12-49	22

Moulting. The process of moulting could not be observed in spring owing to the fact that it lasted for a short period. In the month of December it was observed that the maggot took about five hours to moult. At each moult the larva becomes quiescent, contracts and stops feeding. Gradually the old skin shrinks. The new pharyngeal hooks seem to be lodged in the second segment of the moult. The hooks are moved up and down to rupture the second segment of the old skin dorsally. Immediately the rupture is made the anterior part wriggles out by the forward and backward expansion and contraction of the body. The maggot started feeding soon after moulting.

Pupa. The maggot before pupation greatly contracts and thickens and pupates in the last larval skin which forms the pupiparium. The pupa is formed after undergoing a pre-pupal period of 6 to 12 hours in April and 24 hours in December. The maggots were placed on loose soil and the depth at which they pupated was observed to be as under.

TABLE VII

Depth at which maggots pupated

Date of experiment	Depth in inches	Number of pupae formed
2-4-49	½	23
	1	7
	2	10
	3	8
	4	3
	5	3
	6	12

Evidently pupation takes place in majority within the first three inches in soil but some maggots may travel deeper into a loose soil and pupate as deep as six inches or even more. On harder soil it may take place even on the surface of soil just below the fruit. Usually the maggots leave the fruit for pupation outside the fruit but sometimes the drying state of the fruit may prompt the maggots to pupate within the fruit also. The pest spends a longer period in pupation and the pupae undergo a diapause, i.e., both the short cycle and long cycle pupae are known and the emergence of the flies from the pupae is periodic as will be observed in Table VIII.

TABLE VIII

A. *Duration of short cycle pupae*

Date of pupation	Date of emergence	Pupal period in days
1-4-48	17-4-48	16
3/4-4-48	18/21-4-48	15—17
14-12-48	28-1-49	45
27-3-49	11/12-4-49	15—16
29-3-49	15/16-4-49	17—18
8-4-49	19-4-49	11
5-12-49	25/28-2-50	82—85
	2-3-50	87
6-12-49	22-1-50	47
23-1-50	10-3-50	46
26-3-50	19/26-4-50	24—31
15-3-52	8-4-52	24

From the above it is clear that in case of short cycle pupae the pupal period lasts from 11 to 31 days during March-April and 45 to 87 days in winter. It was also observed that the emergence of males was 1 to 3 days earlier than that of the females.

TABLE VIII—(*contd.*)

B. *Duration of long cycle pupae*

Date of pupation	Number of pupae	Short cycle emergence			Long cycle emergence			Pupal period (days)	Number dead
		Date	Males	Females	Date	Males	Females		
(i) 3-4-49	20	19-4-49	1	..	3-9-49	2	1	153	
		20-4-49	1	1	16-9-49	..	2	166	
		21-4-49	..	1	17-9-49	2	2	167	
					18-9-49	1	1	168	
Total	20		2	2		5	6		5
(ii) 5-12-49	20	25-2-50	2	..	7-8-50	2	..	245	
		28-2-50	..	3	10-8-50	..	1	248	
		2-3-50	2	1	17/18-8-50	2	..	255—256	
					29-8-50	1	..	267	
					14-9-50	1	..	283	
					18-9-50	2	..	287	
Total	20		4	4		8	1		3
(iii) 26-3-50	52	19-4-50	5	3	20-7-50	1	..	116	
		26-4-50	2	3	6-8-50	..	1	133	
					18-8-50	2	1	145	
					28-8-50	2	1	155	
					14-9-50	4	1	172	
					15-9-50	2	4	173	
					16-9-50	2	2	174	
					18-9-50	2	2	176	
					19/20-9-50	2	..	177—178	
					3/4-10-50	4	..	191—192	
					27-10-50	2	..	215	
Total	52		7	6		23	12		4
(iv) Pupae formed during first ten days of April 1950	100	26-4-50	2	1	21-7-50	1	..		
					7-8-50	3	..		
					18-8-50	2	2		
					28-8-50	3	1		
					31-8-50	1	..		
					13-9-50	2	..		
					14-9-50	13	13		
					18-9-50	1	3		
					22-9-50	..	1		
					3-10-50	1	2		
					4-10-50	..	1		
					7-10-50	..	3		
					27-10-50	5	1		
Total	100		2	1		32	27		38

TABLE VIII—(*contd*).

B. *Duration of long cycle pupae*

Date of pupation	No. of pupae	Short cycle emergence			Long cycle emergence			Pupal period (days)	Number dead
		Date	Males	Females	Date	Male	Females		
(v) Pupae formed during 11th to 20th April 1950	68	29-4-50	1	2	20-7-50	1	1		
		1-5-50	2	..	24-7-50	12 unclassified			
		4-5-50	4	2	7-8-50	1	1		
					29-8-50	..	1		
					14-9-50	6	4		
					16-9-50	1	1		
					19-9-50	..	1		
					3-10-50	3	1		
Total	68		7	4		12 unclassified 12	9		24
(vi) Pupae formed during 21st to 30th April 1950	100	8-5-50	5	5	20-7-50	6	14		
		9-5-50	5	..	24-7-50	15 unclassified			
					28-7-50	1	..		
			(Flies emerged were small and weak, two of them were brachypterous.)		25-8-50	1	..		
					26-8-50	1	..		
					14-9-50	1	2		
					16-9-50	1	2		
					18-9-50	2	1		
					19-9-50	..	1		
					20-9-50	1	..		
					3-10-50	1	..		
					4-10-50	1	1		
Total	100		10	5		16 15 unclassified	21		33

TABLE VIII—(*contd.*)

C. *Pupae kept exposed without any soil in petri dishes*

Date of pupation	No. of pupae	Short cycle emergence			Long cycle emergence			Pupals period (days)	Number dead
		Date	Males	Females	Date	Male	Females		
Pupae formed during 11th to 20th April 1950	67	29-4-50	2	..	24-7-50	14 unclassi-fied			
		1-5-50	3	5	7-8-50	4	..		
		2-5-50	..	3	18-8-50	1	..		
		5-5-50	2	..	25-8-50	..	1		
					26-8-50	1	..		
					14-9-50	3	2		
					15-9-50	1	2		
					16-9-50	..	3		
					18-9-50	..	1		
					27-10-50	1	..		
Total	67		7	8		11	9		18
						14 unclassified			
Progressive Total	427		39	30		107	35		125
						41 unclassified			
Emergence %			17%			54%			29%
Sex ratio		Males 56%							
		Females 44%							

From the scrutiny of Table VIII it will thus be observed that 17 per cent of the flies emerge from short cycle pupae and 54 per cent do so after undergoing pupation for a long term which lasted from 133 to 287 days. Mortality in pupal stage is 29 per cent. Two lots of pupae drawn on the same date were kept one (C) exposed to light in a petri dish and another (B. v) covered half an inch with dry soil. There was practically no difference in the emergence of flies from both the cages showing that light had no detrimental effect on the pupae. With a view to find out whether emergence of flies from short cycle pupae was influenced by the rising temperature in April during the close of *ber* fruiting period, pupae formed at 10 days interval were placed separately in petri dishes.

Reference to Table VIII, B(iv), B(v) and B(vi) would reveal that emergence of flies from short cycle pupae did occur even in May when it was pretty hot and the season for *ber* fruit was practically over and chances for further breeding by the fly were nil. The only difference marked was that the flies bred in May were small and weak and some had imperfectly developed wings.

Emergence from pupa

The fly ruptures the anterior part of the pupa longitudinally at its ventral aspect at the junction of 4 and 5 segments of pupa by the pressure exerted by the in and out movement of ptilinum and the front pair of legs. Dorsally the corresponding area of the pupa remains in tact. With the help of hind legs the pupal case is pushed backwards till the fly is completely out. Folded wings of either side run parallel along the mid dorsal line up to the penultimate segment. Before emergence the fly is encased in a thin white integument which is eliminated by the quick movements of legs. The front pair of legs are used to clear head and its appendages and the hind pair of legs are employed turn by turn in quick succession in cleaning wings, thorax and abdomen both dorsally and ventrally. The fly on emergence has its wings folded, the outer margin is inturned under the basal half and furrowed longitudinally.

The fly, having cleaned itself and stretched its wings, avoids all disturbance and stays motionless at one spot for about 2-4 hours to develop its normal colouration. The flies generally emerge between 6 to 9 a.m. in summer and 8 to 11 a.m. in winter. The depth from which the flies can come out from soil was determined and is given in detail in Table IX.

TABLE IX

The emergence of the flies from various depths in loose soil

Date of experiment	Depth at which pupae kept (in inches)	Number of pupae	Emergence in April	Emergence in August to October	Number dead	Per cent emergence
18-4-49	6	20	2	12	6	70
19-4-49	9	30	1	7	22	27
19-4-49	12	40	6	6	28	30
20-4-49	18	50	1	7	42	16

The above figures show that the adult flies are capable of coming out from loose soil 1½ft. deep, though the percentage of emergence is only 16. This emergence through the loose soil is facilitated by the in and out movement of ptilinum, a bulbous structure evaginated from a furrow like depression in the vertex in between the eyes.

In captivity the flies breed with difficulty and all attempts to keep the adult flies alive and make them lay eggs in the breeding cages failed. Different foods like cut fruits of luffa, guava, mango, *ber*, honey solution (1 : 4), mango squash (1 : 4), sugar 5 per cent, glucose (5 to 10 per cent), meat extract and some of them in combination with bacto peptone (2 per cent) yeast, (0·5 per cent) and soaked raisins were tried. The flies lived for only a day without food and for 2 days on water in the month of April. Raisins constituted the best food because the flies lived longer on it than on any other food. The longevity of male was 67 days and that of female 70 days. In one case the adults also lived longer (41-42 days) on 5 per cent glucose which did not constitute a wholesome diet and delayed mating was observed for a short time whereas the adults fed on raisins usually mated within a week. The laboratory bred adults died soon after mating. Where the adults were not allowed to mate, one male lived for 113 days during April to August. It was observed that longevity was dependent on the health of the flies. Laboratory bred adults did not live long and failed to oviposit in captivity whereas the pair caught from the field bred quite successfully. One of the causes for this can be that the maggots generally feed on the pulp under natural conditions and leave the fruit which remains hanging with the tree and provides the maggot with the requisite healthy food to develop and to emerge as well fed larvae. Under laboratory conditions the maggots do not get the food in right consistency because the pulp either begins to dry and gets concentrated in sugar content with the result that pupae formed are small in size. Hence the rsultant flies are weak and die soon. Hagen and Finney [1950] have found that for fruit flies a diet of yeast hydrolysate is not adequate with the addition of honey or sucrose as a source of carbohydrate, an effective combination was found to consist of 20 to 50 per cent yeast hydrolysate solution smeared on wax paper, accompanied by another sheet of wax paper brushed with honey or 80 per cent surcvose solution, with water supplied separately. Solid hydrolysate with solid sucrose was also an effective diet for *Dacus* species. The failure of the flies to breed in captivity was thus largely due to the improper food served. The combination of above foods if served might give the weak laboratory bred adults the strength to successfully breed in the cages. This however is a matter for further investigations as far as this species of fruit fly is concerned.

Seasonal history and number of broods

The pest is active in autumn and spring and the hot summer and the cold months of winter are passed in the pupal stage. The activity of the fly is greatly influenced by the changes in climatic conditions. It was observed that the flies of the first brood emerged between 19 August to 7 October in 1948, between 20 August to 19 October in 1949 and between 19 July to 28 October in 1950. Normally the

emergence of flies takes place from about the 20 August and continues upto the middle of October or in some places even upto November. The peak period of emergence is September. It is in years of early continuous rainfall in July, that emergence of the flies is very erratic and starts earlier than normally due and continues upto the end of October. The *ber* tree flowers in September and fruits are formed by the middle of October. The fruits of *Zizyphus nummularia* are formed a month earlier. In the Punjab there are some varieties which flower in June and are in fruits from September onwards. Thus peak period of emergence generally synchronises with the formation and availability of fruits but how the fly tides over the early period of emergence when *ber* fruit is not available is not definitely known. It is presumed that many of these die. The flies oviposit in the fruits as soon as they are available and in fields the earliest oviposition observed is at the end of October and in the beginning of November. The flies of the second brood start emerging from the end of January and continue upto the middle of March. Oviposition by the flies of second brood is observed in March and the peak period of activity of the fly ranges from mid-March to mid-April when all the stages of the pest are available in the fields. The flies of the third generation emerge by the middle of April and by the time they are sexually mature the season for *ber* fruit is over in Delhi and as the fly has not been observed to breed in any other fruit these flies have no other course but to die, although these have been observed living throughout May and June. At places (Punjab) where some late ripening varieties of *ber* are available in April and May the pest may undergo third generation but in Delhi the study reveals that the pest undergoes only two generations. The pest seems to undergo a similar seasonal history in Uttar Pradesh and Madhya Pradesh but in Baroda the pest makes its first appearance in January and is at peak in February. In Portici the pest is active in summer and over winters in the pupal state thus undergoing only one generation.

Ecology and epidemiology of the pest:

The eggs with in the fruit kept at 33°C shrivelled and died within 24 hours. The maggots within the fruit kept at this temperature were unaffected

TABLE X

Monthly rainfall for five years during which laboratory observations were carried out.

Year	June in.	July in.	August in.	September in.	October in.	Per cent damage	Weekly rainfall inches. in
1948	0·5	7·1	14·9	9·2	0·5		I II III IV
1949	0·1	*18·2	4·1	5·2	0·1	92	*0·1 4·0 10·4 3·7
1950	0·7	†17·9	6·8	6·9	..	65	†1·7 4·6 9·8 1·8
1951	0·6	4·8	3·3	4·0	0·3	10	
1952						60	

and successfully pupated. The pupae formed were small in size and when kept subsequently at room temperature were successfully reared to small

sized flies. Pupae maintained at 33°C and under varying humidities of 20, 45, 65 and 85 revealed that the development of some pupae progressed under all humidity grades with the indication that normal development was affected both by the high temperature and low humidity. The flies obtained were small in each case but under 20 per cent humidity the flies emerged had badly crumpled and ill developed wings which were unable to function normally. It was observed that greater humidity had been conducive to growth and this had been further corroborated by the rainfall and prevailing humidity during the monsoon months. In Table X is given the monthly rainfall data for the years in which the above laboratory observations were carried out.

On reference to Table VIII (i to v) it will be observed that in years of greater rainfall in the month of July when the temperature and relative humidity had been ranging between 80 to 95°F and 70 to 90 per cent respectively the emergence of the flies from long cycle pupae started on about the 20 July in the year 1950. In 1949 also the monthly rainfall in July was high but most of it fell in the latter half of the month hence normal emergence of the flies was not affected. In Uttar Pradesh and Madhya Pradesh the flies emerge in June, possibly due to continuous rains preceding emergence of the flies, but if the rains are delayed and it does not rain enough to cause early emergence, the adult flies emerge normally from about the 20 August onwards. As already stated that in years of early emergence at a time when there is no *ber* fruit the flies die and hence chances of severe infestation of the pest in the following season are much less than in years of late emergence. Much depends upon the continued prevalence of above ranges of temperature and humidity and in accordance with this the degree of infestation of the pest in the succeeding *ber* crop has been observed to be heavy or less. If the above range of temperature and humidity prevails earlier than mid-July the emergence of the flies is early and in consequence the attack of fruit fly in the following season is less. This was the reason why the fruit fly damage in 1951 was less and in other years like 1948, 1949 and 1951 when the precipitation was heavy after mid-July and the emergence of fruit flies was normal, i.e., from 20 August onwards, the damage of the pest in the following spring had been severe. In the spring of 1949, 1950 and 1952 the damage was as high as 92 per cent, 65 per cent and 60 per cent respectively but in 1951 spring following 1950 monsoon period when the emergence of the flies from the pupae was earlier than due, the infestation of the pest was practically negligible.

Thus the above observations lead one to predict about the occurrence of the fly in an epidemic form or otherwise in a particular year dependent upon the preceding monsoon period.

Chemotropism. Citronella and clensel were both exposed in *ber* orchards at periods when the adults had been active but neither of the chemical attractant attracted the flies.

Varietal susceptibility

There are a number of varieties of *ber* fruit which are attacked differently. Soft, sweet, early variety and those providing more pulp generally somewhat round in shape like *gola, dandan, gularwansi* and *daultkhana* are attacked the most. Over 80 per cent damage is recorded in some of them. The varieties like *sunera, khira, katha* and *chhuara* which are more or less cylindrical in

shape, mid-season varieties and are sweet when fully ripe, are attacked upto 30 per cent. The hard, late ripening and less sweet varieties such as *rasmi*, *khatti* or *desi*, *umri*, *bhensrigola* and *seb* are attacked under 10 per cent. Some varieties of *ber* are fully resistant to attack. The fruit of bush *ber* (*Zizyphus nummularia*) is attacked the least both due to less pulp and its sourness when unripe. Sweetness in some degree no doubt is necessary but the soft and pulpy varieties are greatly preferred because the maggots can easily work in.

Parasites

Three parasites of the '*ber*' fruit fly have been reared at Delhi. Two are Braconids and one is Chalcid parasite.

Chalcid parasite. It is the parasite (Plate VIII A, fig. 12) which has been observed to be active in parasitising the maggots of the fly from the very beginning of the pest infestation. The maggot is pierced when it is still young and has not gone into the core. The grub when full fed comes out and pupates by the side of the dead maggot. In the event of egg having been laid in a very young maggot both the host and parasite die. It is when the oviposition takes place in a fairly grown up maggot that the grub of the parasite breeds in it successfully and the adult parasite comes out through a small circular hole (Plate VIII, fig. 4) which is smaller than the exit hole of the host fly (Plate VIII, fig. 3). When both the parasite and host die within the fruit no exit hole is visible on the surface of the attacked fruit. The pupa measures 3 mm.×1 mm. and is smoky dark in colour but becomes jet black at the time of emergence of the adult. The pupal period lasts 21 days. The activity of the parasite synchronises with that of the host but the parasitisation in the fields has been observed to be under five per cent.

Bracon fletchri Silv (Plate VIII A, fig. 10). It is the most active parasite and brings about a fair reduction of the pest. It is found in association with the preceding parasite since the beginning of *ber* fly infestation and is the predominant one during peak period of pest infestation. The grubs of the parasite pupate in the pulp of the fruits in thin white papery cocoon, curved ventro-longitudinally. The cocoon measures 4 mm.×1·5 mm. In the fruits split for examination such cocoons were formed even in the interspaces of *ber* fruit in the breeding cages. In the first generation of the pest the percentage of parasitisation was in the order of 5 per cent but in the second generation it was over 10 per cent.

Opius carpomyiae Silv (Plate VIII A, fig. 13). This pupal parasite of the pest has also been reared in Delhi but its population is very negligible, i.e., hardly one per cent parasitisation occurs. Khare (1923) observed it to be the important parasite of *ber* fly in Madhya Pradesh. He further stated that the activity of the parasite was in great similarity with that of the pest. Another *Braconid* (Plate VIII A, fig. 11) parasite was bred from the *ber* fruit fly in spring.

From the above observations it is clear that the parasites are not enough to check the pest and other methods of control are necessary to save *ber* fruit from loss.

Bionomics

From what has been described above it is deduced that the *ber* fruit fly is an important pest in most places of India and brings about a loss of about 80 per cent of *ber* fruit in years of bad attack. Unlike the *Dacinae* which are active in hot season it is a species which is active during winter season from November to April. The hot season is passed in the pupal stage. In nature the maggots complete their life cycle in the fruit on the tree but in the laboratory at room temperature the fruit could not be maintained in right consistency hence this affected the growth of the maggots which took longer in this stage and the resultant flies emerged were small in size. The larvae leave the fruit through a circular hole on the surface. Pupation takes place in soil 2 to 3 in. below the surface but some pupate even deeper. Some flies are capable of emerging from the pupae buried even at a depth of $1\frac{1}{2}$ ft. in loose soil.

Generally the larvae of several pests are known to undergo diapause but here pupae undergo this phase and both the short cycle and long cycle pupae are known. Longest period spent in pupation was 277 days. Khare [1923] however observed it to be about 300 days. 17 per cent pupae undergo short cycle and three times this number rest for the long period. The emergence of the flies from pupae is very erratic and depends upon the prevailing humidity and temperature. Constant humidity lower than 20 per cent and temperature over 100°F have been observed to be detrimental to the development of the pest in pupation. Flies reared from pupae maintained at 33°C and humidities varying from 20 to 85 were small in size. Similarly the flies reared from larvae in the infested fruit kept at 33°C were also small in size. This development of the flies under abnormal conditions was perhaps responsible for the failure to keep the flies alive in the laboratory although a pair caught from the field successfully bred in the laboratory. The adults fed well on the juice of soaked raisins, *ber* and mango fruits pulp but did not do well on the juice of vegetable fruits. The adults also did not oviposit in any other fruit except *ber* in the laboratory hence the fly is monophagous and breeds in both *Z. jujuba* and *Z. nummularia*. In Italy it breeds in *Z. sativa*. The adult flies are active and sit under the foliage of *ber* and are quick in perception of the approaching danger. They can be collected with difficulty except in copulation or when in act of oviposition. Copulation takes place during the day time and continues for over 10 hours. The fly lays only one egg rarely two in a fruit when it is young but as many as 18 larvae have been bred from a single fully developed fruit and the maximum number of oviposition punctures observed on the surface of a single fruit had been 11. The flies have been observed to oviposit in the fruit at all hours of the day. The adult are long lived and have a life of 67 days in the case of male and 70 days in female, one male lived for 113 days on soaked raisins. The pest undergoes two generations and by the time the third generation flies come out, the *ber* fruit in Delhi is mostly over. Such flies and those that emerge early in July and August may live longer but have not been observed to breed in any other fruit and most probably these die. Where the fruit is available and temperature is also favourable for its breeding the fly may undergo a third generation from April to June.

Z. nummalaria flowers and fruits earlier and some bushes bear fruit even in September hence some flies do try to breed and survive in it but owing to unsuitability of the fruit and less pulp the success of breeding is low. In some localities early varieties of *ber* which begin ripening in September are attacked severely because during this period the emergence of the flies from pupae is at peak. Both the *Chalcid* parasite and *Bracon fletcheri* are active from the very beginning of fly infestation but have not been found to be effective parasites. It is the seasonal factors that mostly govern the occurrence of the pest in epidemic form or otherwise. In years of continuous rainfall during June and July when temperature and relative humidity range between 90 to 95°F and 70 to 90 per cent respectively for most of the period, the adult flies emerge early and finding no food mostly die, hence the attack in the following season is less and that year may not call for any insecticidal treatment ; otherwise in years of normal emergence of the flies in September chemical method of control against the pest is necessary. The adult flies are not attracted to clensel and citronella.

Control

The control of this pest is too difficult a proposition owing to the fact that wild *ber* trees and bushes are scattered about not only in the cultivated fields but almost in many inaccessible places. As the wild *ber* fruit is not much attacked the control measures to be adopted have to be restricted in their application to grafted *ber* groves or orchards.

(1) All the attacked fruit should not be sold off in the market but should be boiled in hot water for half an hour or buried in ground 2 ft. deep and tightly rammed.

(2) The soil below the trees should be dug and kept stirred in the months of May and June so that most of the aestivating pupae are exposed to the hot weather and natural enemies.

(3) The trees should be sprayed with 0·1 per cent Chlordane or 0·1 per cent BHC after the middle of October so as to kill the adults before they lay eggs in the fruits.

(4) Sweetened poison bait as recommended in case of other fruit flies should also be tried between the middle of February and middle of March to kill the adults. Both the methods 3 and 4 promise a good success but require to be thoroughly tried to fix the formulations and to find out correct time of their application for effective control.

Dacus ferrugineus Fabricius

D. ferrugineus is active throughout summer. The known host plants number exceeds 50. The first fruit attacked in Delhi is *ber* (*Zizyphus jujuba*) in April. The record of *ber* as a host of this species is the first one. May is passed in loquat fruit. June is scarcity period as far as the food of the fly is concerned. During this period it has been observed to oviposit in very hard and unripe pears and brinjal fruits. If no other suitable host plant is available a drop in the population of immature stages occurs. Early varieties of peach or Chinese peach ripen in June

and they are heavily infested. From 32 fruits of Chinese peach 792 adult flies were reared by the end of June. The flies consisted of two species, *D. ferrugineus* and *D. zonatus* and their analysis is shown in Table XI.

TABLE XI

Analysis of flies belonging to two species

Species	Male flies	Female flies	Total
D. ferrugineus	352	347	699
D. zonatus	21	25	46
	Ill developed and unidentifiable		47
		Total	792

The flies reared per fruit on an average numbered 25. This is three times the number that I have so far reared from a giant size peach 6A in the North-West Frontier Province (Pakistan).

The maximum number of maggots so far observed in a single fruit had been 111 in guava. The highest record of the number of maggots infesting a single fruit is 156 in case of *D. dorsalis* Hendel in mango and 637 of *D. cucurbitae* in pumpkin from Hawaii. This is due to the lack of sufficient food for the pest but at the same time is indicative of the severity of the pest in a country. However, it is generally due to several females having oviposited in the same fruit. The flies reared under such circumstances are generally smaller in size than those of normally developed ones.

The peak period of the fly, July to October, is passed in mango, pear and guava. Guava is the most favoured host and the soft pulp varieties are highly susceptible. The hard pulp variety like the Allahabad guava is attacked very much less and should greatly be encouraged as a measure of control against the pest. Growing of soft pulp varieties should completely be abandoned and eradicated from the orchards. No breeding has yet been observed in citrus at Delhi nor the adult flies have been collected from the orchards after October. Presumably the fly over winters as pupa from November to March.

Attraction to clensel

Contrary to the results obtained so far by Pruthi and Bhatia [1938], Batra [1941], Trehan and Pingle [1946] and Shah, Batra and Renjhen [1948] in the attraction of 50 to 60 per cent of female flies to clensel attractant the author has observed at Delhi that clensel when exposed in dilution of 1 : 19 with water in the fruit orchards attracted only the male flies and the attraction of females

was almost negligible. This further proves that clensel reacts differently under varying climatic conditions. Hutson [1938] reported similar results from Ceylon. It failed to attract either sex of the fly when exposed in Parachinar (NWFP) in August 1947. It evidently shows that means of control of *D. ferrugineus* by means of chemical attractants should further be tapped. The male flies of this species are also attracted to citronella oil, pollard mixture, vanilla, liquid ammonia, bay oil, iso-eugenol, methyl-eugenol, flowers of papaya, Australian cycad and *Colocassia antiquorum*.

Dacus zonatus Saunders

D. zonatus is commonly found in association with *D. ferrugineus* and is next to *D. ferrugineus* in its importance as a pest of fruit orchards. The number of host plants recorded so far is about eighteen. A great competition exists in the struggle for existence between the two species. It seems *D. ferrugineus* is aggressive and is rapidly displacing this species in the localities where sometimes back it had the sway. From the numerals quoted under *D. ferrugineus* where both these species have been reared from Chinese peach it will be apparent that proportion of *D. zonatus* is 1/15 of the population of *D. ferrugineus*. It is just possible that as several varieties of *D. ferrugineus* like *ferrugineus*, *pedestris*, *incisus* and *versicolor* interbreed resulting in *Dacus ferrugineus* as the dominant species [Munro, 1939]. The same may apply to *D. zonatus* which in course of time might dwindle away as a result of interbreeding with *D. ferrugineus* which seems to be a dominant species. The above points offer rich field for further study. At present the fly is active in summer and over winters in the pupal stage. The adults have been observed to take shelter under the bushes during early winter. Throughout summer it is closely associated with *D. ferrugineus* and breeds in the fruits in different months of the year as recorded in case of *D. ferrugineus*. In this species also only the males are attracted to clensel in Delhi. The males are also attracted to citronella, methyl-eugenol, inflorescence of Australian cycad and *Colocassia antiquorum*.

Dacus cucurbitae Coquillett

The list of its host plants is on the increase and well over 70 host plants are on record in the countries in which it is found but in India it is a specific pest of cucurbit vegetables and breeds in other fruits like guava, peach, date palm and citrus only when the cucurbit fruits are scarce or when atmospheric temperature rises upto 100°F and relative humidity falls below 40 degrees. Such weather prevails in Delhi in the months of May, June and September. The melon fly then migrates to fruit orchards or shady bushes where the temperature is comparatively low and humidity high, the fly in the absence of cucurbit fruits may oviposit in any of the above fruits if in season, otherwise generally the breeding remains restricted and the population of the flies greatly dwindles down. At this time of the year *D. ciliatus ciliatus* is very active because it favours the climate unsuitable for *D. cucurbitae*. During July when the rains set in and the early summer passes into monsoon both the above species are found even in the same fruit. When both temperature

and humidity are at optimum level *D. cucurbitae* is the only species active and population of *D. ciliatus ciliatus* dwindles away. When the temperature again rises and humidity falls in September, the population of the former goes down and that of the latter increases. In November the adults of both the species are found under the foliage of *ber* (*Zizyphus jujuba*) plantations to feed on the honey dew of insects. *Dacus ciliatus* gradually goes into pupation for winter but *D. cucurbitae* continues to breed till late December. The fly over winters in the adult stage under the leaves of guava, loquat and bushes in association with *D. diversus*. The population of *D. cucurbitae* is low as compared to that of *D. diversus*. It is the first species to be seen on wings in March and subsists on the honey dew of the sucking insects and juices oozing out of the cut surface of fruits. From the study made both in the field as well as in the laboratory it has been observed that gravid females are more active in egg laying from midday onwards to afternoons under shade while during the evenings in the fields. From July to October its parasites *Opius fleetcheri* Silv. is also active and greatly holds it in check. The male flies are attracted to clensel but too less in number.

Dacus ciliatus ciliatus (Loew)

According to Munro [1948] there are two forms of *Dacus ciliatus*, (i) *ciliatus ciliatus* (ii) *ciliatus frontalis*. The former has a single hypopleural spot and is found in the Oriental and Ethiopean regions whereas the latter has a double hypopleural spot and is so far confined to the African region. Over dozen food plants are known and it breeds exclusively in cucurbit fruits. However, it is known to attack citrus in Eritrea. Its bionomics has been given under *D. cucurbitae*. The species has been observed to oviposit in its host plants both at morning and evening hours and is not known to be attracted by any attractant. The male fly is attracted to clensel very rarely.

D. cucurbitae and *D. ciliatus ciliatus* seem to be compatible and not aggressive in their designs against each other and both breed out successfully from the same fruit to continue their progeny.

Conclusion

The biology of *D. diversus* which was not known has been described. Biology and control of *Carpomyia vesuviana* and its epidemiology have been studied in greater detail. So far known bionomics of *D. diversus*, *Carpomyia vesuviana*, *D. ferrugineus*, *D. zonatus*, *D. cucurbitae* and *D. ciliatus ciliatus* have been clearly outlined in each case. It is evident that one or the other species of fruit flies is always found in the fields and calls for attention for control which is yet far from satisfaction. It was expected that females of some species of fruit flies would be attracted to clensel but this proved to be a failure on an experimented trial under Delhi conditions. The problem is thus of complex nature and needs further research both on the applied and fundamental aspect to find out rational means of control.

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THE SOILS OF THE VINDHYAN PLATEAU IN THE MIRZAPUR DISTRICT OF UTTAR PRADESH

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THE district of Mirzapur, from where the soil profiles reported in this paper were collected, is in the extreme south-east of Uttar Pradesh in the last tiers of the districts in the State. The district lies between the parallels of 23°52′ and 25°32′ north latitude, and 82°7′ and 83°33′ east longitude. The physical aspect of the district presents a variety of landscape but the country can broadly be divided into three great topographical divisions. These are (i) the Ganges valley in the north consisting of the alluvial plains, (ii) the Vindhyan plateau in the centre upto the Kaimur range with an average elevation of 500 feet above the valley of the Ganges and (iii) the Sonpar in the south comprising the Son valley and the adjoining area south of the Kaimurs. A regular soil survey of the district is in progress from the Regional Soil Laboratory, Banaras, under the Soil Survey Organization of the Uttar Pradesh Government.

The soils reported in the present paper were sampled from the Vindhyan table land of the Mirzapur district. This plateau is some 70 miles in extent from east to west and varies from 20 to 30 miles in width from north to south containing an area of about 1700 to 1800 square miles. The southern boundary is formed by the Kaimur range. The level of the plateau is by no means uniform and there is a well defined slope towards the west. The soils of the plateau are generally a stiff and shallow red clay interpersed with large areas of excellent fine black soil, resembling the black cotton soil of Bundelkhand. The nature of the soil depends upon the elevation of the cultivable areas in the tableland.

Geologically, the Vindhyan tableland in this district consists principally of Upper Vindhyan sandstones. The subdivisions of these which can be found are upper and lower Kaimur sandstones, Upper Rewa sandstones and Rewa and Bijaigarh States. The lower Kaimur sandstones and Bijaigarh slates occur specially in the south of the plateau, while the upper Kaimur sandstones constitute the greater part of the tableland. The Rewa shales and sandstones are found only at the western limits of the district.

The largest percentage of the cultivated areas of these soils is covered by paddy in the *kharif* which constitutes about 38 per cent of the total area cropped in this season. The paddy grown on the Vindhyan plateau is mostly of the late or transplanted type, known as *jarhan* which is of superior quality and yields a larger outturn than the early paddy. The sandy type of soils which have less moisture retentive capacity grow *bajra* or *guar* mixed with *arhar*. The proportion of this mixed crop in the area is about 25 per cent of the *kharif* area. Other crops grown in the *kharif*

are *til* and smaller millets. Gram, barley and wheat, alone or mixed with each other, form the main *rabi* crops in the order given. These altogether occupy about 72 per cent of the total cropped area in the *rabi*. The remainder of the *rabi* harvest is taken up by linseed, peas and mustards. The system of agriculture followed is of the most primitive type and consequently the yields are very poor. There are no means of irrigation and fertilisers are not in use anywhere. The population is sparse and freer use of fallowing the land is the only practical method resorted for preserving the fertility of the soil [Drake-Brockman, 1911].

Climate. Records of rainfall for the Vindhyan plateau can be obtained from the data of the observatory of the Indian Meteorological Department at Robertsganj. Since this area lies immediately below the Kaimurs, it receives slightly more rainfall than either the northern or the southern portions of the district. The average for the plateau is about 45·5 inches. Annual variations are considerable, the wettest years on record have shown a rainfall of 73·8 inches. The years, on the other hand, in which the rainfall has been in marked deficiency are few, and in one of such years Robertsganj received 32·90 inches of rain. No regular thermometrical observations have been kept in Mirzapur, but the absolute temperature varies from 109°F. in June to 28°F. in December, the average maximum being about 90°F. and the average minimum about 65°F. for the whole year.

Methods of analysis and survey. Survey methods similar to those reported in other publications from this laboratory were adopted in these investigations. Ultimately, one typical profile representing the red upland soil and two profiles representing the lowland soils were sampled for detailed studies. Out of the two lowland soils one was yellowish-brown and the other grey or black in colour. The usual morphological characteristics were recorded *in situ* on the freshly cut profiles. Colour of soil was studied on the standard Munshel Soil Colour Charts.

Two millimeter samples were used for all analytical work. Mechanical analysis was carried out by the International pipette method. Hydrochloric acid extract was prepared and analysed in the usual manner. The glass electrode was used for the determination of *p*H values in aqueous media. Exchangeable bases were estimated by the ammonium acetate method. Clay isolates were analysed after fusion with sodium carbonate as for ordinary silicate analysis.

Experimental

The morphological characters of the three soil profiles are given in Table I.

Table I

Morphological characters of the three soil profiles

Soil type	Horizons	Depth in inches	Description
Red	A	0-6	Reddish brown (5YR5/4) becomes dark reddish brown (2·5YR3/4) when wet; coarse grained; loosely packed; non-calcareous and neutral.
	B	6-15 15-36	Red (2·5YR4/6) becomes dusky red (10R3/4) when wet; coarse sand particles are cemented by clay; closely packed with hard consistency; prismatic and slightly acidic.
	C	Below 36	Semi-decomposed rocks and boulders with *morram*.

TABLE I—*contd.*

Morphological characters of the three soil profiles—contd.

Soil type	Horizons	Depth in inches	Description
Brown	A	0-9	Light yellowish brown (10YR 6/4) tending to be dark yellowish brown (10YR 4/4) when wet; loam; loose; single grained; faintly alkaline; friable consistency and non-calcareous.
		9-21	
	B_1	21-36	Light yellowish brown (10 YR 6/4) to yellowish brown (10YR 5/4); loam to clay-loam in texture, impregnated thinly with iron nodules; hard consistency; non-calcareous and netural to alkaline in reaction.
		36-48	
	B_2	Below 48	Fine sand with signs of water-logging.
Black	A	0-9	Light grey (2.5Y7/2) becomes grey-brown (2·5Y5/2) when wet and appears black in transmitted light; clayey; cloddy in structure; neutral; compact and non-calcareous.
	B_1	9-21	Grey brown (2·5Y6/2) more clayey than above; impregnated with *kanker* (limestone nodules); cloddy and alkaline in reaction.
		21-33	
	B_2	33-45	Same as above but the soil begins to be slightly friable.
	C	Below 45	Whitish grey material thickly set with small sized *kankers*; water standing at the bottom.

It will be seen that whereas the red soil profile is very shallow with the bed rock within three to four feet of the surface, the other two profiles show greater depth of the soil. The A-horizons in the first two profiles are less clayey than the horizons lying below them but the process of the eluviation of clay is not so prominent in the case of the black soil profile. Since the soils have developed over sandstone parent material which is not very rich in lime, the profiles do not show much calcareousness, except in the B-horizons of the black soil profile where also the soil is only slightly calcareous.

The red soil profile had a coarse clayey loam texture and the structure of the B-horizon is prismatic being of a hard consistency and indurated. In the case of the brown and black profiles the B-horizon was again slightly indurated. All these factors are clearly visible from the results of the mechanical analyses of the three soil profiles, detailed data for which are given in Table II.

TABLE II

Mechanical composition of soil types

Soil type	Depth in inches	Coarse sand (2·0-0.2 mm.)	Fine sand (0·2-0·02 mm.)	Silt (0·02-0·002 mm.)	Clay (0·002 mm.)
Red	0-6	13·78	43·52	22·35	18·94
	6-15	14·05	26·91	32·59	26·17
	15-36	14·07	28·51	19·01	37·50
Brown	0-9	4·45	50·62	22·90	20·40
	9-21	4·14	39·96	33·75	21·80
	21-36	5·47	29·22	27·17	38·04
	36-48	5·05	29·27	20·05	42·10
Black	0-9	1·37	37·18	19·45	39·60
	9-21	1·17	33·16	18·90	42·95
	21-33	1·28	34·62	19·85	40·00
	33-48	0·92	42·32	20·40	35·85

Red soil type. The soils of this type are the richest in coarse sand as compared with the other associated types. This is evidently due to its higher topographical position in the catena. The percentage of coarse sand is almost uniform in the three layers of the profile. But it may vary in other areas showing more coarse sand fractions in lower layers of other profiles of this soil type. Fine sand, on the other hand, is more in the A-horizon, which also contains comparatively less silt and clay. It appears that the physical translocation of finer fractions both downwards in the profile and also its transport through erosion to areas of lower topography are well marked in this soil type. The B-horizon of this profile accordingly presents an indurated character. The texture of the top layer is coarse clayey loam giving an open and thirsty appearance.

Brown soil type. The coarse sand fraction in this type is not as high as in the red soil type, but the top layer turns out to be predominantly sandy with a fine sand content as high as 50 per cent. The texture of the lower layer of the A-horizon becomes slightly heavier due to a higher percentage of silt. The B-horizon contains a higher percentage of clay and silt and clay together form about 62 to 65 per cent of the soil material in this horizon. The B-horizon accordingly shows a very heavy clayey texture.

Black soil type. The predominant character of the black soil type is its uniform clayey nature upto a depth of six feet, the clay content being as high as 40 per cent in some layers. The illuviated B-horizon in this type comes nearer the surface since this soil type does not allow greater translocation due to its low lying position. For the same reasons the difference in the clay contents between the A and B horizons is also not very pronounced. Broadly speaking, the textural composition of the entire profile may be taken as constant in all the layers. However, the coarse sand content is very low and the main sand fraction consists of its finer variety. Accordingly, the texture of this type of soil is heavy clay.

Table III contains the results of the analyses of the hydrochloric acid extracts of the 2 mm. sieved portions of the soils.

TABLE III

Composition of the hydrochloric acid extracts

(per cent dry basis)

Soil type	Depth in inches	Loss on ignition	Insolubles	Fe_2O_3	Al_2O_3	P_2O_5	CaO	MgO	K_2O	CO_2	Water solubles
Red	0-6	3·94	80·59	7·12	6·00	0·074	0·224	0·302	0·264	*nil.*	·063
	6-15	5·59	74·00	8·68	8·73	0·080	0·336	0·323	0·293	*nil.*	·052
	15-36	6·25	66·43	11·12	9·26	0·096	0·364	0·403	0·365	*nil.*	·038
Brown	0-9	2·69	85·97	3·56	4·97	0·024	0·35	0·26	0·37	*nil.*	0·10
	9-21	3·58	79·70	4·64	8·06	0·024	0·35	0·25	0·55	*nil.*	0·058
	21-36	4·39	75·35	5·80	9·68	0·025	0·48	0·40	0·55	*nil.*	0·066
	36-48	3·52	76·95	5·12	8·76	0·031	0·20	0·36	0·53	*nil.*	0·048
Black	0-9	3·81	76·16	5·36	8·57	0·040	0·56	0·42	0·31	*nil.*	0·08
	9-21	4·92	72·48	6·12	10·15	0·046	0·74	0·79	0·77	0·05	0·098
	21-33	4·45	72·93	6·04	10·48	0·043	0·87	0·64	0·36	1·00	0·123
	33-48	3·90	74·43	5·80	9·02	0·031	1·01	0·79	0·46	1·05	0·116

An inspection of the data for the chemical composition of the extracts confirms all the inferences made earlier for the soil types on the basis of their morphological and textural characteristics. The broad significant points are discussed below :

Red soil type. Loss-on-ignition figures in this profile follow the same trend as clay. Acid insolubles are the maximum at the surface layer which is predominantly richer in the sand fractions. Iron and alumina exhibit a tendency of accumulation in the depth in precisely the same order as clay. The profile seems particularly poor in alkaline-earth metals and also in potash although these constituents show a trend of leaching in the profile. There are no insoluble carbonates and the contents of water soluble salts are low. All these characteristics exhibit a leached type of soil formation which has been caused by the higher topographical position and open texture of the profile. The profile contains extremely low quantities of total phosphorus.

Brown soil type. Loss-on-ignition figures are in the same order as the clay contents in the profile, except in the last layer where the clay content is the highest, but the loss-on-ignition is comparatively less. The two layers of the A-horizon being more sandy than the succeeding two layers of the B-horizon, contain more acid insolubles. Iron and alumina show a gradual tendency of movement in the bottom layers and the behaviour of alumina is more striking in this respect since it accumulates particularly in the layers immediately below A-horizon. Like the red soil type, the contents of alkaline-earth metals are low although the potash contents are slightly better in comparison. The phosphorus percentage is even lower than that in the red soil profile. There is no trace of insoluble lime carbonates and the contents of water soluble salts are average. The profile has developed under slightly impeded drainage, but its comparatively sandy texture in the surface allows movement of alkaline-earth bases, although its water-logged nature during the rains is partly responsible for higher salt contents of secondary origin in the profile.

Black soil type. The soil of the surface layer in the profile gives less loss-on-ignition and more acid insoluble residue as compared to the layers below it. This is evidently due to its higher sand content. The sand content of the last layer is also higher and here again less loss-on-ignition and more acid insolubles have been found. The A-horizon is lower in sesquioxides as compared to the B_1-horizon, although the B_2-horizon again comes out to be more silicious. Lime and magnesia are in largest amount in the B-horizon which also turns out to be calcareous showing the presence of insoluble carbonates. Water soluble salts are high particularly in the B-horizon layers. The distribution of potash is erratic and the contents of phosphorus in all the layers are poor.

The results of general analysis and data for the exchangeable bases are given in Table IV.

TABLE IV

General analysis and composition of the exchangeable bases (per cent dry basis)

Soil type	Depth in inches	Water holding capacity	*p*H	Organic C	Total nitrogen	Exchangeables					Calcium saturation
						Total bases	Ca	Mg	K	Na	
Red	0-6	42·2	6·7	0·76	0·078	12·4	5·6	3·6	1·93	1·27	45·1
	6-15	44·9	6·7	1·06	0·072	16·0	8·6	3·2	2·29	1·91	53·8
	15-36	46·9	6·8	0·79	0·081	17·6	9·6	3·6	2·40	2·00	54.5
Brown	0-9	42·2	8·1	0·464	0·058	16·0	9·4	3·2	2·6	0·8	58·7
	9-21	45·0	7·0	0·384	0·053	15·2	8·0	3·6	2·04	1·56	52·6
	21-36	47·5	7·3	0·296	0·047	16·4	9·4	3·2	1·56	2·24	57·3
	36-48	46·3	7·4	0·232	0·042	19·2	12·2	3·8	1·93	1·27	63·5
Black	0-9	48.5	7·8	0·632	0·062	21·6	12·6	6·4	1·56	1·04	59·5
	9-21	54·3	8·5	0·584	0·050	24·8	14·6	6·4	2·40	1·40	59·4
	21-33	54·5	9·25	0·272	0·042	34·0	24·2	7·0	2·29	0·51	71·2
	33-48	53·4	9·0	0·232	0·037	31·2	21·6	7·4	0·96	1·24	69·2

Water holding capacity follows the same trend as that of clay in the profiles, except in the last layers of the brown and black soil profiles where greater water holding capacity has been found with comparatively less clay percentages. This is evidently due to the water-logged nature of these layers whereby the silt also acquires some colloidal properties. The *p*H values for the different layers of the three soil profiles present interesting development characteristics. The red soil profile shows *p*H values which are slightly below 7. With the exception of the top layer of the brown soil profile which has given a marked alkaline *p*H value, other layers show only slightly higher *p*H values than 7. The black soil profile exhibits marked alkaline *p*H values. In all the three cases, there is a tendency for the soil reaction to assume acidic character with improvement in the drainage status of the profile in conformity with the lime status of the three profiles. Organic carbon and total nitrogen figures are not very low in the first two layers of the three profiles which is one of the typical characteristic of all tropical paddy soils.

In regard to base status of the exchange complex, it may be mentioned that the predominant cations in the complex are composed of the divalents. There is a tendency for the bi-valent saturation to decrease slightly with maturation in the soil profiles. The saturation with potassium is high signifying very high nutrient status for this ion in all the soil types. The percentage saturation with sodium is low and even in the bottom land black soil profile it does not go over 15 per cent of the total bases signifying that the physical condition of all the layers are good enough for water movement in the profile. The total base exchange capacity has a tendency to increase with depth due to greater clay contents in the lower layers of the first two profiles and marked water-logged nature of the third profile.

The results of the fusion analyses of the separated clay fractions from soils of the three profiles and the calculated molecular ratios are given in Table V.

TABLE V

Ultimate analyses of the clay fractions

(*per cent dry basis*)

Soil type	Depth in inches	Base ex. capacity	Loss on ignition	SiO_2	R_2O_3	Fe_2O_3	Al_2O_3	MgO	K_2O	Molecular ratios	
										SiO_2/R_2O_3	SiO_2/Al_2O_3
Red	0-6	53·00	18·10	34·40	41·30	12·40	28·90	2·02	2·35	1·586	2·018
	6-15	56·50	17·10	34·06	42·00	12·80	26·60	2·22	2·93	1·578	2·062
	15-36	52·50	16·26	35·28	42·90	12·80	30·10	1·81	2·40	1·567	1·992
Brown	0-9	67·50	17·54	35·46	40·30	10·80	29·50	2·02	3·27	1·657	2·044
	9-21	61·00	16·48	36·56	42·10	10·80	31·30	1·51	2·00	1·629	1·984
	21-36	62·00	15·56	36·83	41·60	10·40	31·40	2·41	2·43	1·647	1·995
	36-48	64·00	15·96	36·60	41·80	10·40	31·40	2·41	1·93	1·637	1·982
Black	0-9	84·50	17·60	38·32	37·50	10·40	27·10	1·01	2·62	1·932	2·404
	9-21	75·00	16·60	38·56	39·50	11·20	28·30	1·61	2·50	1·849	2·317
	21-33	81·50	17·50	38·92	36·20	9·20	27·00	2·02	2·76	2·014	2·452
	33-48	67·50	16·50	41·34	35·30	9·60	25·70	1·81	2·62	2·178	2·695

A comparative study of the distribution of silica and sesquioxides in the clay fractions of the three profiles (Table V) gives interesting pedological information. The average silica content in all the layers of the three profiles is in the same order as their descending topographical positions in the catena. The high lying red soil profile contains, on an average, slightly less silica than the profiles in lower positions. But, the contents of the sesquioxides are just in the reverse order. Of the sesquioxides, iron seems to have a more marked tendency of accumulation with increase in the degree of leaching than alumina. The contents of magnesia and potash are small in all the three profiles and they do not indicate any regular variation with either the degree of maturation or leaching in the soil profiles. The local climatic conditions favour intense weathering in the hot season and transport of weathered material with water during the rains. The rainfall being heavy, i.e. 45 inches per annum, complete removal of the products of weathering is possible on sites provided with adequate drainage. The resulting soil material left over seems to be poor in silica and rich in sesquioxides, a process that signifies weak laterisation. However, the fact that even the leached red-soil profile cannot be considered as typical laterite or even lateritic is supported by the inspection of the actual figures for iron and aluminium in the clays of the different layers of the soil profiles and also from the calculated values for their silica sesquioxides and silica-alumina molecular ratios. The average silica-sesquioxides and silica-alumina ratios for the clays of the three profiles in accordance with the above clay composition tend to be in an increasing

order with the maturation of the soil profiles. The total exchange capacity and loss of moisture of the clays also follow the same trend as their silica-sesquioxides ratios in the three profiles. A joint consideration of all these facts suggests that the low-lying black soil profile may be richer in the montmorillonitic minerals than the high-lying red soils. This can only be taken as a mere suggestion until data for the mineralogical composition for the three soils are available.

Within the profile the composition of the clay colloids appears to be remarkably constant and consequently the silica-sesquioxides and silica-alumina ratios for the different layers of each of the three soil profiles give, within limits, constant figures. In the red and brown soil types the silica-alumina ratios show a value very much near two, which is suggestive of the fact that the pedogenic factors of the soil types approach the limits of laterization and that slight change in these conditions may have made these soil actually laterite in formation.

Summary

Soils of the Vindhyan plateau in the Mirzapur District of Uttar Pradesh have been described in the present paper. Three distinct types, viz. the red, the brown and the black, have been recognized which occupy three topographic positions in the catena.

Mechanical, chemical and physico-chemical analysis of the three soil types have been given in the paper and the results of analysis discussed pedologically.

The data on the ultimate composition of clay fractions from the three soil types signify a process of weak laterization but the soils cannot be considered as typical laterites or even lateritic. Within the individual profiles the clay composition appears to be remarkably constant, the silica-alumina ratios approaching a valve of two.

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SYSTEMATIC INVESTIGATION OF SOIL ORGANIC MATTER WITH PARTICULAR EMPHASIS ON THE SOIL HYDROLYSATES OF AGRA SOIL

II. PRELIMINARY ANALYSIS OF THE HYDROLYSABLE ORGANIC MATTER IN THE SOIL

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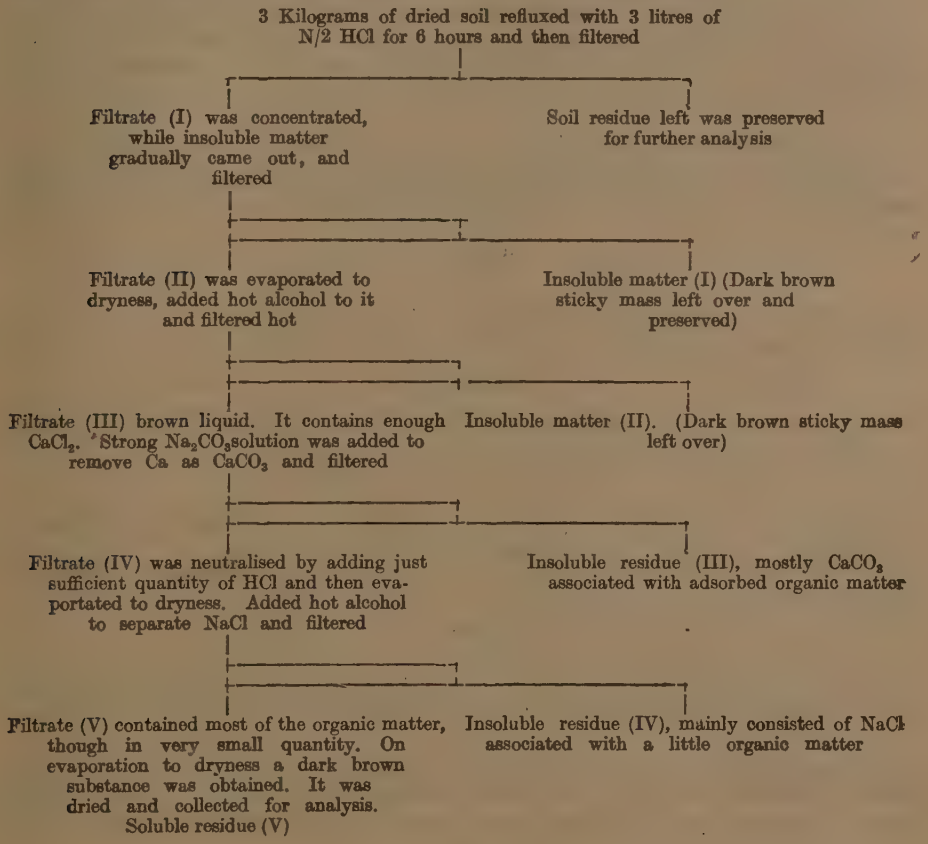
IN continuation of our previous communication on the systematic investigation of soil organic matter with particular emphasis on the hydrolysates of the Agra soil, we have been able to elucidate further the chemical aspect of humus by analysing the insoluble fractions shown in the following sketch.



It was communicated in Part I of this series that the soil hydrolysatés contain a nitrogen compound and a carbohydrate in most cases and in some fractions sulphur is also present. The chief inorganic elements are iron, aluminum, calcium, magnesium and chlorine. The acid radicals such as phosphates and sulphates have also been found. Kojima [1947] and Bremner [1949] have established that at least one third of organic nitrogen of the Rothamsted soil is of protein nature and they have been able to identify a number of amino-acids as a result of preliminary examination by paper chromatography.

We have on the other hand attempted to separate at first the inorganic and the organic matter in the soil hydrolysates by trying various organic solvents.

Experiments on the solvent action by the various organic solvents on the 'insoluble matter I' (vide *sketch page 121*)

It was observed that benzene, ether, carbon tetrachloride, petroleum-ether acetone, toluene and chloroform had practically no solvent action on this residue, while acetic acid, mixture of acetone and alcohol and mixture of alcohol and ether gave certain amount of soluble fraction leaving a greater portion of insoluble residue.

Insoluble matter (I) was digested with three solvents (1) acetic acid, (2) acetone-alcohol and (3) alcohol-ether. The elementary analysis of the soluble and insoluble fractions obtained from each of the solvents have been shown in Table I.

TABLE I

Analyses of the soluble and insoluble fractions

Acetic acid		Acetone-alcohol		Alcohol-ether	
Soluble	Insoluble (A)	Soluble	Insoluble (B)	Soluble	Insoluble (C)
N and S absent. Only chlorine present	Brown residue. N, S and Cl all present	N and S absent. Only chlorine present	N, S and Cl all present	N and S absent. Only chlorine present	N, S and Cl all present

N=Nitrogen S=Sulphur Cl=Chlorine

Table I shows that the soluble fractions of each solvent contain only chlorine, while the insoluble fractions contain nitrogen, sulphur and chlorine in all cases.

The insoluble portion (B) obtained by repeatedly digesting in acetone-alcohol as shown in Table I, was then treated with water and the elementary analyses of the water-soluble and water-insoluble fractions was also performed as given in Table II.

TABLE II

Analyses of water soluble and water-insoluble fractions

Insoluble fraction (B) containing nitrogen, sulphur and chlorine treated with water and filtered	
Insoluble	**Soluble**
Nitrogen and sulphur absent and only a very small amount of chlorine was detected by elementary analysis. Some organic chloro-compounds suspected	Nitrogen, sulphur and chlorine present. By $AgNO_3$ a white curdy precipitate insoluble in nitric acid was obtained. Inorganic chloride and some soluble ionisable organic base-chloride suspected

Since no compound could be indentified in the above mentioned solvent extracts, the insoluble fraction I (*vide* sketch, page 121) was soxhletised in benzene vapour for 20 hours, when a brown solution was obtained. On evaporation an acidic residue (melting point 83°C) was left in which nitrogen, sulphur and chlorine were absent. This residue on heating with B-naphthol and concentrated sulphuric acid gave the test for glycollic acid (green florescence). It was further confirmed by oxidising the substance when it gave the test for an oxalate.

In our previous communication we observed that fraction (I) and the soluble residue (V) gave positive Molisch's Test. We have been able to identify the carbohydrates in soluble residue (V) as galactose and cellobiose from the chracteristic shapes of the osazone crystals obtained by the standard method.* Feilitzen and Tollen [1898] obtained the following sugars in the hydrolysates of high moor peat (one per cent sulphuric acid for 1½ hours at 130° to 135°C.) :

Mannose, galactose, levulose and pentose.

Insoluble fraction (II) and the soluble residue (V) (*vide* sketch, page 121) were soxhletised for 20 hours in the solvents—benzene, chloroform and acetone. In each

TABLE III

Qualitative analysis of soxhletised fractions

Fractions	Solvents			
	Benzene	**Chloroform**	**Acetone**	**Ether**
Insoluble fraction (II)	Yellow substanee obtained on evaporation of the solvent. N (faint) present, S and Cl absent. On burning no residue left. No action on litmus.	Sharp needle-shaped crystals and some gummy mass. No action on litmus. N (faint), S and Cl absent. Ne residue on burning	A black gummy substance leaves residue on burning. N(faint), Cl present and S absent. No action on litmus	On keeping for 30 hours practically no soluble matter could be extracted.
Soluble residue, (V)	White and yellow mixed crystals, leaves very little residue on burning. N, S and Cl all absent. Molisch's test positive. No action on litmus.	Light yellowish needle-shaped crystals mixed with gummy mass. N present only. No action on litmus.	Gummy mass associated with fernlike crystals	Kept for 28 hours in the refrigerator, on evaporation of the extract very small amount of organic substance containing N was obtained.

*Practical organic chemistry by Arthur I Vogel, p. 442 and plate .

case small amounts of organic matter having well defined physical characteristics, were obtained on evaporation of the solvent as shown in Table III.

The Tables I, II and III have given us some qualitative knowledge of solvent action on the soil hydrolysates and much experimental work is in progress to prepare the extracts in larger quantities and identify the compounds by systematic examination. It is yet too early for us to report finally on the nature of organic components of the hydrolysates of Agra soil.

Summary

Acid hydrolysates of Agra soil have been studied to detect the organic components of the un-manured soil of the botanical garden of Agra College. It has been found that in some fractions of the soil hydrolysate, glycollic acid and galactose are present. By elementary analysis nitrogen, sulphur and chlorine have been detected. Action of various solvents on the insoluble and soluble fractions of the hydrolysates has been observed.

Acknowledgement

Thanks are due to Dr S. P. Raychaudhuri of the Indian Agricultural Research Institute, New Delhi, for his valuable suggestions and helpful criticism.

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STUDIES IN THE VARIATION OF PHYSICAL PROPERTIES OF HUMIFIED CLAYS

III. VARIATION OF THE TOTAL EXCHANGEABLE BASES IN THE HYDRATED CLAYS, WHEN MIXED WITH RAW ORGANIC MATTER SUCH AS COW-DUNG, TREE LEAVES AND VEGETABLE LEAVES, WITH THE PERIOD OF HUMIFICATION UNDER LABORATORY CONDITIONS

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In previous papers our investigations on the changes in physical properties, such as conductivity, *p*H and base exchange capacity of Simultala, Raj Mahal and Kasim Bazar clays under natural conditions were communicated.

In those experiments, the clays were taken in earthenware flower pots which were embedded in the garden soil up to their neck. The humification of the clays was brought about by mixing them with raw organic matter such as leaves or cow-dung followed by regular addition of water at every 24 hours.

Base exchange phenomenon has already been studied elaborately by many workers, but the variations in the total exchangeable bases of primary clays during their hydration as well as their artificial humification does not seem to have attracted sufficient attention.

Mukherji [1942, 1945, 1947] and Raychaudhuri and co-workers [1940, 1942] have extensively worked on the electro-chemical properties and base exchange capacities of the Indian soils as well as on Bentonite clays and have established interesting results correlating the properties of such clays and those of the parent minerals ; we have carried out our investigations by taking three varieties of clays (Simultala, Raj Mahal and Kasim Bazar) as parent bodies and have studied the changes in the total exchangeable bases with time under laboratory conditions, when the pure clays are hydrated and when they are humified by mixing with raw organic matter such as leaves of *neem*, *peepal*, spinach, cauliflower and *murena* (a kind of grass) and cow-dung in the hydrated conditions. Similar experiments have been carried out with the natural (uncultivated) soil of Agra taken from the garden of Agra College for comparative study.

Experimental

The gradual humification of clays was performed as follows under the laboratory conditions :

Equally weighed amounts of soil, Kasim Bazar, Raj Mahal and Simultala clays were taken in separate glass pots. Organic matter such as green leaves or cow-dung were added separately to these clays and also to the soil in the ratio of eight parts of clay to three parts of organic matter. Water was added to these pots.

The samples of these clays were taken from each pot and dried in open air. This dried sample was powdered and sieved (0·5 mm.).

Determination of the total exchangeable bases

The total exchangeable bases of the samples were determined by the method of Schofield [Piper 'Soil and Plant Analysis' page 189 of 1947]. The observed figures of the exchangeable bases were corrected for the carbonate contents of the samples.

Observations

Table I

Total exchangeable bases during humification m.e. per 100 gm.

Time in days	Hydrated alone	Mixed with cow-dung hydrated	Mixed with *neem* leaves & hydrated	Mixed with cauliflower leaves and hydrated	Mixed with spinach leaves and hydrated	Mixed with *murena* leaves and hydrated
			Soil			
0	28·13	28·13	28·13	74·26	74·26	74·26
14	26·86	33·11	17·97	72	59·83	54·54
28	25·66	38·39	17·59	62·35	65·60	62·94
42	23·75	25·24	18·7	69·27	58·53	57·74
56	30·21	11·61	21·86	71·63	73·17	61·60
70	25·09	34·94	26·69	82·86	72·68	78·03
84	25·68	32·18	41·64	92·82	74·74	76·56
98	31·23	39·24	26·66	81·85	83·33	66·18
112	29·93	33·86	29·15	88·40	71·21	80·45
			Simultala Clay			
0	14·06	14·06	14·06	14·06	14·06	14·06
14	12·91	47·29	17·18	15·57	15·20	0
28	7·18	25·27	11·47	19·69	16·8	14·84
42	9·96	26·38	9·73	18·14	12·19	13·00
56	14·91	22·48	15·77	16·90	22·31	15·6
70	9·89	26·10	20·91	19·22	16·46	19·6
84	8·56	16·29	31·82	13·14	20·23	16·40
98	11·28	29·01	22·83	23·79	31·01	14·03
112	23·70	24·41	22·67	23·60	16·66	16·54

Total exchangeable bases during humification m.e. per 100 gm.

TABLE I—*contd.*

Time in days	Hydrated alone	Mixed with cow-dung and hydrated	Mixed with *neem* leaves and hydrated	Mixed with cauliflower leaves and hydrated	Mixed with spinach leaves and hydrated	Mixed with *murena* leaves and hydrated
			Raj Mahal Clay			
0	14·06	14·06	14·06	14·06	14·06	14·06
14	8·98	17·56	14·06	15·56	13·6	·41
28	4·68	28·77	9·94	17·81	15·2	17·53
42	6·11	28·68	6·00	17·32	17·07	25·62
56	7·49	18·31	10·04	20·52	17·07	26·00
70	15·00	26·55	10·59	19·52	19·67	33·33
84	9·19	31·23	22·00	19·92	19·84	39·84
98	18·11	29·52	14·16	24·95	21·31	34·18
112	10·22	23·33	16·19	27·2	18·94	42·85
			Kasim Bazar Clay			
0	25·85	25·85	25·85	25·85	25·85	25·85
14	15·15	31·75	9·76	23·36	21·20	13·22
28	9·76	32·94	13·76	19·43	23·60	21·07
42	15·67	34·03	26·50	21·44	23·57	19·50
56	15·73	33·33	19·67	22·55	16·26	22·40
70	17·90	23·69	17·92	25·09	26·16	27·75
84	15·47	36·44	22·78	29·08	27·62	23·43
98	13·38	38·25	22·83	27·01	22·86	21·81
112	23·62	26·66	23·48	31·06	25·00	22·19

DISCUSSION

1. In the hydrated clays *unmixed with any organic matter* the total exchangeable bases at first decrease and then increase up to a certain period, after which there is again an alternate rise and fall up to the total period of observations (112 days).

2. The hydrated Agra soil shows similar behaviour.

3. When the clays are mixed with cow-dung, there is at first a rise in the total exchangeable bases followed by a decrease up to a certain period after which there is an alternate rise and fall. It may be noted with interest that in the clays humified

by cow-dung the total exchangeable bases although fluctuating, remained above that of normal clays during the whole period of our observation (112 days).

4. The soil also showed similar behaviour except for a short period in the middle, when its total exchangeable bases go down.

5. With *neem* green leaves the behaviour of the clays with respect to their total exchangeable bases seems to be reverse of that observed by cow-dung humification. We observed that *neem* leaf humification in the majority of cases showed a fall in total exchangeable bases at first and then a rise followed by an alternate fall and rise. The change in the total exchangeable bases of clays by *neem* leaves was much less than that in the case of cow-dung and the values were not very much higher than the total exchangeable bases of the normal clays. Similar was the result with the local soil.

6. With cauliflower leaves the total exchangeable bases increased at first in Simultala and Raj Mahal clays, and then decreased upto a certain period, followed by a rise and fall during the period of humification. The reverse of this took place with the local soil and Kasim Bazar clay.

7. With spinach leaves, the local soil, Raj Mahal and Kasim Bazar clays at first showed a decrease followed by increase while with Simultala an increase in total exchangeable bases took place followed by a fall.

8. The total exchangeable bases in the clays humified by cauliflower and spinach leaves were always higher in majority of cases than that of the normal clays (unhumified).

9. When humified with *murena* (a kind of weed which grows in the wheat fields), the clays and the local soil showed a decrease in the total exchangeable bases in the first stage followed by alternate increase and decrease during the period of investigation (112 days). The values of total exchangeable bases were not very much higher than those of normal clays, except in the case of Raj Mahal clay.

From Table I, it can be generalised that there is a decrease in the total exchangeable bases in the first stage when the local soil was humified by green leaves of *neem*, cauliflower, spinach and *murena* and the same result was obtained in the majority of clays also. In some cases, however, there was an increase in the total exchangeable bases with green leaves in the first stage, but it was not so high as in the case of cow-dung.

The fall in the total exchangeable bases during the first stage of hydration in absence of any external organic matter seems to be due to the hydrolysis of the clays. When the clays are hydrolysed, hydrogen ions are formed in the solution from silicic acid. These hydrogen ions may be responsible to remove some of the bases from the clay particles whereby the total exchangeable bases decrease in the first stage of hydration. At a later stage, the aluminium hydroxide formed by hydrolysis will absorb the bases from the solution, showing a rise in the total exchangeable bases. Such processes appear to take place during the hydration of clays and soil also.

In the case of cow-dung-mixed clay, the total exchangeable bases increase in the first stage. This increase seems to be not only due to the formation of humus but also due to the residual fibrous matter and adsorptive substances that result from the decomposition of cow-dung. The alternate fall and rise in the total exchangeable bases appear to be due to hydrolysis and adsorption. The whole process is a function of many factors which are complicated by the decomposition of organic matter.

The total exchangeable bases with leaves do not increase so much as with cow-dung. This observation suggests that the decomposition products of cow-dung are more adsorptive than those of leaves.

Summary

The variations of the total exchangeable bases in the hydrated Simultala, Raj Mahal and Kasim Bazar clays mixed with raw organic matter such as cow-dung, tree leaves and some vegetable leaves have been studied at different periods of humification under laboratory condition. The changes in the total exchangeable bases of Agra soil under identical conditions of hydration and humification have also been studied to make a comparative study of the behaviour of clays and soil.

The values of the total exchangeable bases at different intervals of hydration and humification when plotted against time in days showed a periodicity in all cases. The cow-dung showed a greater increase in the total exchangeable bases than the leaves.

The changes in the total exchangeable bases during humification have been explained as being due to hydrolysis and adsorption.

Acknowledgement

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STUDIES ON TILLAGE

I. EFFECT OF SEED-BED PREPARATION, WITH ALTERNATIVE FORMS OF IMPLEMENTS, ON THE YIELD OF WHEAT

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(With two text-figures)

TILLAGE is one of the oldest of the farmers' arts and, perhaps, the least understood branch of agricultural science. In the opinion of Russell 'it has received less aid from science (apart from engineering) than any of them'. The accumulated experience of many generations, by the slow process of trial and error, developed the system of cultivation to a high stage of perfection. In the traditional knowledge of the farmer, no doubt, there are many hidden scientific principles. Nevertheless, just as in other arts, considerable development has been reached in the design of implements.

A great variety of implements sprang into existence between 1840 and 1875 to meet the demand of farmers. Yet, in spite of this great advance, the essential nature of implements was not changed. Unlike the thresher and the binder, which are in no sense adaptations of the flail and the sickle, the tillage implements of today would be recognised without difficulty by the farmer of two centuries ago. He would also immediately recognize the actual operations. We have still to repeat the same old series of operations to produce 'tilth'. Tillage is still the most costly single item in arable farming.

The necessity for inquiry into cultivation matters is, therefore, obvious and needs exploration. Unfortunately, though there are innumerable manurial experiments, the tillage experiments recorded in the literature are relatively few. It is, perhaps, because the tillage is so universal that it has been taken for granted to be carried out without further scientific knowledge.

With the above background in view an experiment was started by the writer in 1942 when the Karnal Sub-station of this Institute was under his charge. The results of five years are presented in this paper.

Experimental

The investigation reported in this paper was carried out with the object of studying 'the effect of seed bed preparation, with alternative forms of tillage implements, on the yield of wheat'.

The experiment was laid out in a split-plot design on an irrigated piece of land known as 'general area' at Karnal. The treatments consisted of bullock *versus* tractor cultivation with the following detail.

Treatments

1. Power cultivation with tractor implements (7 in.)—Soil inverting plough followed by cultivator and harrow.

2. Bullock cultivation with soil inversion (4 to 5 in.)—Victory plough supplemented with local country plough.
3. Bullock cultivation without soil inversion (4 to 5 in.).
   (i) Local country plough
   (ii) *Bakhar* (blade harrow)

Small sub-plots (249 in.×33 in.) oriented from the above cultivated strips were treated as follows: The manurial dose was initially light, but had to be increased later.

A	No manure.
B	Sulphate of ammonia at 60 lb. N per acre.
C	Farm yard manure at 60 lb. N per acre.
D	A mixture of sulphate of ammonia and F. Y. M. at 40 lb. N per acre.

There was no rotation fixed, and wheat followed wheat every year. The purpose of the study was to observe the difference produced by the culture, with various implements, over a number of years, irrespective of the yield.

The project was started in *rabi* 1942 with an area of 47 acres of land and continued on the same place for a period of six years. The data obtained during the concluding year, unfortunately, was very heterogeneous due, perhaps, to abnormal conditions in that year, and has been excluded from the study.

Soil used for the investigation was a sandy loam containing the physical composition as shown in Table I.

TABLE I

Physical composition of soil (percentages)

Soil separates	Surface soil (0 in.—6 in.) per cent	Sub-soil (6 in.—18 in.) per cent
Clay	17·13	20·34
Silt	23·02	24·38
Sand	56·72	52·32

An idea of its chemical nature may be had from Table II.

TABLE II

Chemical composition of soil (percentages)

Depth	Loss on ignition	Sand and silica	Total				Available		Organic N
			CaO	MgO	K_2O	P_2O_5	K_2O	P_2O_5	
Surface soil (0 in.—6 in.).	2·86	85·6	0·38	0·61	0·882	0·066	0·016	0·015	0·073
Sub-soil (6 in.—18 in.).	2·79	53·37	0·41	0·85	0·865	0·067	0·010	0·007	0·049

On the whole, the soil was light and, rather, of low fertility. It was badly infested with pernicious weeds especially those of *Sorghum helepense* (*barru*) and *Convolvulus arvensis* (*lepatni*). Weeds put great obstruction in cultivating land properly during the first year, and hence *bakhar* which was not found to be a suitable implement under such conditions was dropped from the test.

With the prolongation of war it became increasingly difficult to procure machinery or even spare parts for them. The condition of equipment, therefore, deteriorated so much as to necessitate the curtailment of area to half in 1944.

In general, treatment No. 1 received 1 or 2 ploughings, two discings and 2 or 3 grubbings (cultivator); while two ploughings with 'victory' followed by 8 or 9 with 'country' were given to treatment No. 2. There were in all 12 ploughings done to treatment No. 3 by country plough.

In order to have a general picture of the work, the data from different years was pooled. Since there were four main-plot treatments in 1942, and the area was reduced to half in 1944 and onwards, hence the results for first two years have been shown separately. For subsequent years (1944 to 1946-47) a combined analysis indicating the overall effect of cultural treatments, seasonal variations and the interaction between seasons and cultural treatments after testing the homogeneity of error variance by 'M' test, was done. The data for 1947-48 could not be linked with previous years as the error variance for this year was very high and heterogeneous.

The statistical analysis indicated significant differences between cultural treatments and between years, but the interaction between years and cultural treatments was not found significant. The results of statistical analysis are given in Tables III and IV.

TABLE III

Results of statistical analysis

Cultural treatments	Yield in maunds per acre		
	1942-43	1943-44	1944, 1946-47
Tractor implements-plough cultivator and disc.	13·72	13·21	10·98
Victory-*cum*-country plough	10·62	11·91	12·65
Country plough	11·37	10·26	10·95
Bakhar	10·33	..	..
'F' test	Significant	Significant	Significant
S. Em	=0·60	=0·69	=0·19
C. D. at 5 per cent	1·90	2·37	1·16

It is evident from Table III that except for the first year, when tractor plots gave significantly higher yield over the rest, there was a gradual decline in yield for the remaining period. Treatment No. 2, showed progressive increase in yield, becoming significantly higher during the last three years combined. Ploughing with 'country' alone, however, was not effective.

TABLE IV

Showing yields of individual years (1944, 1946-47)

Cultural treatments	Yield in maunds per acre		
	1944-45	1945-46	1946-47
Tractor implements	9·30	15·80	7·83
Victory-*cum*-country plough	10·53	18·50	8·93
Country plough	8·29	16·59	7·98
S. Em =0·59			

It appears from the Table IV that victory-*cum*-country ploughing has, in *each* year given higher yield, than the other treatments, thus making a progressive increase in the average. It is also evident that a favourable season in 1945-46 has not only benefited 'victory' but also equally the others.

The interaction between cultural treatments and manures was, on the whole, not significant. Between sub-plots, however, the difference was significant in favour, as expected, of the higher manurial dose.

As the main object of the investigation was to study the cultural difference or its interaction with manures, mere difference between manurial treatment has, therefore, not been considered.

DISCUSSION

On further examination of the results, certain facts are clearly brought out. Relatively deep ploughing coupled with soil inversion hastened to clear the land of weeds by the tractor, thus pushing up yield in the first year. Shallow inversion by bullock implements was slow in action and started showing itself only in the second year. During subsequent years, however, it was significant enough to outyield the former. It appears the weeds had so established themselves, without any rotation, as to make time-honoured cultivation by 'country' plough futile.

These findings have been confirmed by numerous workers. Keen and his co-workers at Rothemsted have demonstrated that there was no advantage in ploughing deeper than four inches. Stamerie [1950] reported on the basis of over 14 years of trials to compare 4 in. and 7 in. ploughing on light soils that for crops such as maize and oats, deep ploughing was not necessary. Low, and then Allan

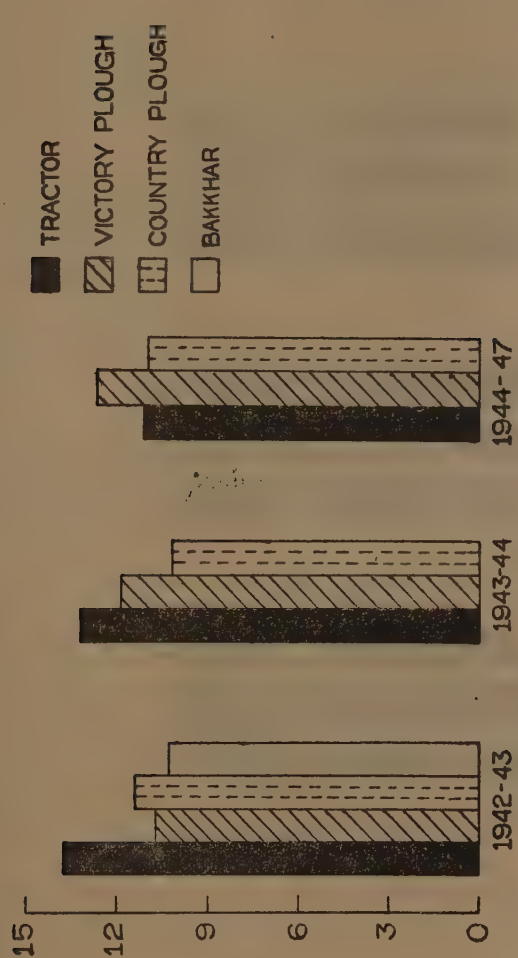

FIG. 1. Tillage experiment at Karnal

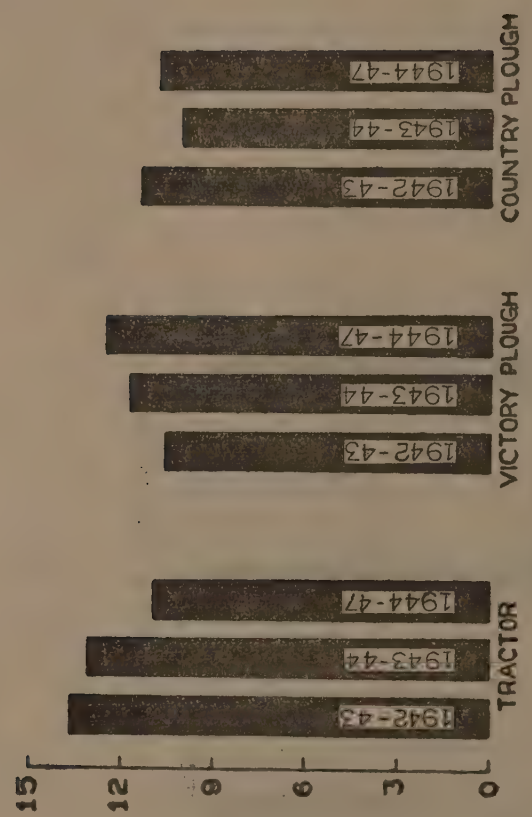

Fig. 2. Tillage experiment at Karnal

have shown the superiority of inversion by bullock ploughs in trials conducted over many years. Such examples can be cited and infinitum.

In the case of tractor cultivation it has been observed that it tends to pulverise the soil too much. This encourages its packing after irrigation is given, or rain occurs. The air-moisture relationship is thus disturbed, with the result that crop suffers. Mechanised cultivation permits speed in work and enables a larger area to be cropped, it does not however, necessarily ensure bigger yields. For reclaiming lands badly infested with weeds, it has no parallel.

Summary and conclusion

The results discussed in this paper lead us to the following conclusions.

The favourable effect of soil inversion in case of bullock implements is marked.

Greater depths secured by tractor implements were not conducive to bigger yields.

A shallower depth without inversion is not, under weedy conditions conducive to satisfactory yield.

Acknowledgment

Thanks are due to Dr T. J. Mirchandani, Head of the Division of Agronomy, Indian Agricultural Research Institute, New Delhi, for going through the manuscript and helpful suggestions. Thanks are also due to Mr. Kavitkar for miscellaneous help in pooling the data.

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INVESTIGATIONS ON THE PREPARATION AND USE OF SWEET POTATO AND GROUNDNUT CAKE FLOURS IN CONJUNCTION WITH WHEAT FOR LEAVENED BREAD (*DABAL ROTI*) AND *CHAPATIS*

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INDIA continues to be grossly deficient in supplies of food grains of which shortage of wheat is of particular interest as no other food grain by itself possesses the faculty of being processed into bread of the type generally produced from wheat. The importation of huge quantities of wheat grains from abroad is a very heavy drain upon the financial resources of our country, so, in the interest of national economy the desirability of making the available stocks last longer by partially supplementing them with edible flours from other sources hardly needs any emphasis. Singh, *et al.* [1943] made a notable contribution towards the achievement of this end by finding out the optimum proportions of the coarse food grains such as barley, maize, millet, gram, etc. which can be incorporated with wheat without unduly affecting the acceptability and palatability of bread made from such mixture. With a similar objective in view, the investigations reported in this paper were carried out by employing sweet potato and groundnut cake flour as blends with wheat for preparation of *chapatis* (unleavened pan cakes) and *dabal roti* (leavened bread).

Materials and methods

Preparation of flours

Sweet potato flour. The sweet potato flour employed in these investigations was prepared from a local variety of the roots in two different ways, viz. (i) from unscalded tubers and (ii) from scalded tubers. To begin with the sweet potato roots were washed and peeled and then chopped into thin slices (approximately $\frac{1}{8}$ in. thick). At this stage the thin slices were divided into two lots, one of which was dried directly until brittle and then finally ground fine in the Laboratory Mill and thereafter passed through a set of sieves having 18, 30, 50 and 72 meshes per linear inch. The flour so produced was found to be of greyish hue in comparison with pure wheat flour, which is generally creamy-white. This might be attributed to the enzymatic oxidation which caused a blackening of the surface of the slices during the process of drying. The second lot of the raw tubers was immediately immersed in boiling water and scalded for two minutes, after which they were dried and ground to flour as in the case of first lot. The flour so prepared turned out to be of a creamy-white colour. The scalding operation had counteracted the adverse activity of the oxidising enzymes which were mainly responsible for causing blackening of the slices of raw roots while being directly dried.

Groundnut cake flour. A sample of groundnut cake was obtained from the Provincial Marketing Officer, Madras, at the instance of the Indian Council of Agricultural Research. It was ground into fine flour in the Laboratory Mill. The finely-ground material was bolted through a fine cloth sieve having 72 meshes per linear inch. The flour, on account of its softness, was found to stick to and clog the meshes of the sieve. This difficulty was, however, overcome by adding a few maize grains to the flour in the sieve during the sifting operations. This particular sample of the cake on analysis was found to contain 56·8 per cent protein, 11·1 per cent oil, and 6·5 per cent ash (results on moisture-free basis).

Wheat flour. *Atta* (whole meal) and flours employed in the studies were ground in the Laboratory Experimental Roller Mill.

Baking tests

(*a*) Chapatis *from wheat* atta *and sweet potato flour mixtures.* In the first set of these experiments, sweet potato flour obtained from unscalded tubers was used. The *chapatis* were prepared from different blends of wheat *atta* in which the proportion of sweet potato flour varied from 10 to 60 per cent and also from pure wheat *atta* and sweet potato flour for comparison. In the second set of these tests, the sweet potato flour prepared from scalded tubers was mixed with *atta* in proportions ranging from 10 to 50 per cent.

(*b*) Chapatis *from wheat—groundnut cake flour mixtures.* In this test *chapatis* were prepared from mixtures of groundnut cake flour and wheat *atta* in which the amount of the former varied from 5 to 70 per cent. Weighed quantity of the dough was taken for making *chapatis.* Observations in respect of the various quality characteristics of the *chapatis* such as 'colour', 'texture', 'taste' and 'dough behaviour', etc. were recorded on a comparative basis.

(*c*) Dabal roti (*leavened bread*) *from wheat—sweet potato and wheat groundnut cake flour mixtures.* The sweet potato flour was blended with wheat flour in proportions of 1, 2, 5, 10,15, 20, 25 and 30 per cent, respectively, whereas groundnut cake flour was mixed in proportions of 5, 10, 15, 25 and 50 per cent, respectively. Loaves were prepared from the various blends as also from pure wheat flour by using baker's yeast (*Saccharomyces cerevisea*) as a leavening agent in accordance with the standard baking procedure of the American Association of Cereal Chemists [1941]. The loaves so prepared were judged for quality in terms of 'loaf volume', 'type', 'grain', 'texture', 'crust', and 'crumb' characteristics represented numerically by the quality score number. The various quality characteristics are briefly explained below:

Loaf volume. The size of a loaf measured in c. c. by placing the cooled loaf in a compartment of known volume and allowing rape seed to run in from the bottom nozzle of a wide calibrated burette until full. The excess of the seed is struck off from the edges and the contents of the container emptied in a trough, the loaf removed and the residual seed allowed to fall into the burette through a funnel at the top. The volume of rape seed in the burette is recorded and by substracting from the known volume of the compartment, correct volume of the loaf is arrived

at. The higher the volume, the better the quality of the material from which the bread is baked.

Grain. It refers to the cellular structure of the bread crumb, 'grain' being fine or coarse according as the cell size is small or large. The quality of the grain is denoted by numbers rising from No. 1 (coarsest) to No. 6 (finest).

Texture. Softness and resiliency or toughness of the bread crumb or of the fresh *chapatis*.

Crumb. The interior cellular surface of a cut loaf.

Crust. The top surface of a loaf is its crust.

Loaf type. By this term is meant the type of external appearance of the loaf of bread and is indicative of the quality of the flour or blends from which it is made. Traits such as symmetry, size, smoothness or ruggedness, etc. determine the loaf type and is designated by alphabetic letters.

Quality score no. This is a numerical index of the good and bad points of a loaf arrived at by summing up marks assigned to important quality characteristics of the loaf. The higher the figure, the better the comparative quality of the loaf and the raw materials from which it is prepared.

Results and discussion

Dough-behaviour and chapati *making quality of sweet potato flour and wheat* atta *blends*

The results of first set of these experiments in which sweet potato flour obtained from unscalded tubers was used are presented in Table I.

Table I

Effect of incorporating sweet potato flour with wheat atta *on the dough behaviour and* chapati *making quality of the blends*

Proportions in mixtures		Water absorption c.c. per cent	Dough behaviour	*Chapati* characteristics			
Wheat per cent	Sweet-potato per cent			Weight in (*) fresh state gm.	Colour	Texture	Taste
100	0	88·0	Lax, fair	40·0	White	Tough	Non-sweetish.
90	10	86·7	Rather stiff	38·8	Greyish	Do.	Almost wheat like
80	20	85·4	Do. (Manageable)	39·8		Do.	Do.
70	30	84·1	Do. (Manageable)	38·7		Do.	Slightly sweetish
60	40	82·8	Tends to produce holes during flattening	37·5	Greyishness increases progressively	Do.	More sweetish
50	50	81·5	Do. Tends to increase	36·5		Do.	Distinctly more sweetish
40	60	80·2	Unmanageable	38·7		Not as tough	Very sweetish
0	100	75·0	Difficult to bake, cracks and holes appear in the *chapati*, easily susceptible to charring	..	Grey	Soggy	Very sweetish taste of boiled sweet-potatoes

(*) *Chapatis* were baked from 50 gm. dough in each case

Up to the level of 30 per cent of sweet potato flour in the mixture, the resulting dough, though less elastic than that of pure wheat *atta*, was quite manageable. At 40 per cent level of sweet potato flour in the mixture, however, the dough tended to be somewhat 'short', the dough breaking here and there while being rolled into *chapatis* prior to baking and subsequently resulting in the development of holes in the finished product. At 50 per cent level, there was an intensification of this tendency, yet *chapatis* could be made without any serious difficulty. At 60 per cent level of admixture, the resulting dough became extremely short and at the same time too soggy and sticky to be 'manageable'. The corresponding *chapatis* were found to be susceptible to charring on the baking plate, tending more to be like pure sweet potato *chapatis* which charred easily on the hot baking plate and possessed characteristic darkish colour. In fact, greyish tinge appears in *chapatis* containing even 10 per cent sweet potato flour and the tendency appeared to be intensified with increase in the proportion of the sweet potato flour in the mixture. But, in taste, up to 20 per cent of sweet potato flour in the mixture, there was no marked departure of mixed-stuff *chapatis* from pure wheat *chapatis*. Sweetishness in taste began to be felt distinctly from 30 per cent level and *chapatis* with a content of 50 per cent of sweet potato flour tasted almost like boiled sweet potato.

The results of experiments in which flour of scalded tubers was employed are summarized in Table II.

TABLE II

Effect of incorporating sweet potato flour of scalded tubers with wheat atta *in the dough behaviour and* chapati-*making quality of the blends*

Proportions in mixtures		Water absorption c.c. per cent	Dough behaviour	*Chapati* characteristics			
Wheat	Sweet potato			Weight in fresh state gm (*)	Colour	Texture	Taste
100	0	80	Good	41·3	Yellowish white	Fairly soft	Nonsweetish
90	10	87	Do.	42·6	Whitish	Softer	Do.
80	20	94	Do.	43·3	Do.	Still softer	Slightly sweetish
70	30	101	Do.	44·0	Greyish white	Very soft, silky and velvety to touch	Distinctly sweet
60	40	108	Do.	43·3	Do.	Do.	Sweeter
50	50	115	Satisfactory	42·6	Do.	Do.	Still sweeter Tastes like sweet potato
0	100	150	Do.	not taken	Pinkish greyish white	Do.	Do.

(*) *Chapatis* were baked from 50 gm. dough in each case

It was noticed that the use of flour from scalded tubers in the blends brought about considerable improvement in a number of ways. In the first place, water

absorption of the mixed *atta* increased substantially since it was found that this type of sweet potato flour, on being kneaded into dough, absorbed 150 per cent water as agginst 75 per cent similarly absorbed by flour from unscalded tubers (Table I) and 88 per cent by wheat *atta*. The scalding operation, besides inactivating the undesirable enzymes, caused partial geletinization of the starch of the tubers, which, in turn, not only prevented 'shortness' in dough but also improved the handling properties of the dough so much that no difficulty was felt in preparing *chapatis* from a mixed stuff containing as much as 60 per cent of the sweet potato flour. To prepare *chapatis* even from pure sweet potato flour of this type was not found difficult. The colour and texture of the mixed *chapatis* improved considerably. Up to 20 per cent level in the mixture, the colour was whitish, and from 30 to 50 per cent increasingly greyish white, but quite tolerable. At and above 30 per cent level of admixture, the *chapatis* were soft, silky velvety and pliable to touch. They took longer to stale then pure wheat *chapatis*, which in fact became stale quickest of all. The tardiness of staling varied in direct proportion of the sweet potato flour content in the *chapatis*. As regards taste, the sweetishness of *chapatis* beyond 10 per cent increased with the proportionate increase in the amount of sweet potato flour in the mixtures until at 50 per cent level, the taste was characteristic of boiled sweet potato.

Groundnut cake flour and wheat atta *blends.*

The results are presented in Table III.

TABLE III

Effect of incorporating groundnut cake flour with wheat atta *on the dough behaviour and* chapati-*making quality of the blends*

Proportions in the mixture		Water absorption c.c. per cent	Dough behaviour	*Weight in fresh state gm.	*Chapati* characteristics		
Wheat	G. N. cake per cent				Colour	Texture	Taste
100	0	88	Good	66	Creamy white	Slightly tough	Wheat-like
95	5	88	Do.	65	Greyish white	Do.	Do.
90	10	88	Fair	65	Intolerably grey	Soft and silky to touch.	Lacks in wheat taste
80	20	88	Do.	65	Distinct greyish red	Do.	Flat, insipid, characteristic of G. N. cake grittiness
70	30	88	Do.	65	Do.	Do.	Increased insipidness and grittiness
50	50	83	Sticky	65	Reddish grey	Do.	Do.
30	70	83	Do.	65	Do.	Do.	Increased insipidness and bitter

* *Chapatis* were prepared from 75 gm. dough in each case

It was surprising to notice that the addition of five per cent of groundnut cake flour to wheat *atta* imparted a greyish tinge to the *chapatis*, and this greyishness intensified with further additions of the cake flour, becoming distinctly marked at and beyond 10 per cent limit. But, the 'texture' of the *chapatis* improved somewhat, the *chapatis* being soft and silky to touch in contrast with the slightly tough 'texture' of pure wheat *chapatis*. The extensibility of dough and taste of *chapatis*, however, suffered badly on reaching the 10 per cent level. At and above 20 per cent level of the cake flour in the blends, the taste of the *chapatis* became intolerable specially on account of the presence of extraneous matter such as sand and grit in the cake. The amount of groundnut cake flour which can go well with wheat *atta* for making *chapatis* should not exceed five per cent. However, this limit can be exceeded, provided it were commercially possible to have sand, or dust-free, and skin-free cake, but the colour of such mixed *chapatis* would be another serious defect which would adversely affected the attractability of the product.

Leavened bread (Dabal roti) *from wheat-sweet potato flour mixtures.* The results of this study are presented in Table IV.

TABLE IV

Dabal roti (*leavened bread*) *making quality of wheat-sweet potato mixtures*

Proportions in the mixture		Water absorption per cent	Loaf characteristics						Quality score
wheat	Sweet potato		Crust	Crumb	Texture	Grain No.	Type	Vol. c.c.	
100	0	73·2	Brown and even	Creamy white	Slightly tough	4	J	405	51·5
99	1	72·0	Do.	Greyish	Slightly tough and resilient	3	J	405	47·5
98	2	72·0	Do.	Grey colour increases.	Do.	3	J	422	49·2
95	5	72·5	Dirty tinge and rugged	Distinct grey	More tough but resilient	3	J	420	48·0
90	10	73·5	More dirty and rugged	Dark grey	Very tough	under developed 3	I	368	36·8
85	15	74·0	Very dirty and rugged	Do.	Do.	under developed 2	I	350	32·0
80	20	74·5	Grey and very ruggedly	Do.	Do.	Do.	G.I.	360	31·0
75	25	75·0	Do.	Do.	Hard	under developed	G.I.	315	15·5
70	30	75·5	Dark grey and very rugged	Do.	Do.	Do. Soggy	G.I.	282	12·2

J—A symmetrical loaf of medium size and of smooth and unbroken exterior.
I—A loaf with a rugged exterior which results from excessive toughness and elasticity in the flour gluten.
G.I.—The loaf between G and I the former having a break in the centre of the crust while the latter having a rugged exterior.

The results contained in Table IV show that incorporation of 1, 2 and 5 per cent of sweet potato flour with wheat flour produced a satisfactory loaf. In fact, the

loaf volume of the latter two blends was higher than that of the wheat flour loaf, the ' grain ' and the ' texture ', appeared normal, but an increasing greyish tinge appeared in the ' crumb ' and ' crust ' of the loaves. The ' crust ' of the five per cent blend loaf was slightly rugged and beyond this limit all the loaf characteristics were adversely affected. The ' crust ' became more rugged, the ' texture ' very tough and the ' grain ' progressively under-developed and the ' volume ' smaller and smaller. The baking trial showed that mixing of sweet potato flour with wheat flour for purposes of leavened bread should be restricted to a limit of five per cent of the sweet potato flour in the blends. The taste of such a loaf would approach that of the loaf prepared from pure wheat flour.

Dabal roti *from wheat-groundnut cake flour mixtures.* The results of this study have been summarized in Table V.

TABLE V

Dabal roti *making quality of wheat groundnut cake flour mixtures*

Proportions in the mixture		Water absorption c.c. per cent	Loaf characteristics						
wheat	cake		Crust	Crumb	Texture	Grain No.	Type	Vol. c.c.	Quality score No.
100	0	88	Brown	Creamy white	Slightly tough	4	J	460	56·0
95	5	88	Do.	Greyish white	Do.	4	JF*	520	63·0
90	10	88	Do.	Whitish grey	Increased toughness	3 under developed	J	475	51·5
85	15	88	Darkish brown	Increased grey	Soggy	2-3 under developed	J	445	39·5
75	25	88	Dirty brown	Do.	More Soggy	under developed	I	405	28·5
50	50	88	Do.	Dirty grey	Miserably soggy	Do.	I	309	15·0

* A loaf slightly below a standard loaf and resembling more the J type referred in foot note under Table IV

The results show that the addition of five per cent groundnut cake flour in the mixture produced bread which was similar to the bread made from wheat flour alone. In certain ways it was superior to the latter, e.g. in respect of volume but the colour of its crumb was greyish white as against creamy white of pure wheat flour bread. Beyond five per cent limit, however, an all round progressive degeneration in the quality characteristics of the loaf took place. The ' crumb ' colour tended to be more and more darkish, the 'grain' coarser and coarser and the'volume' smaller and smaller with proportionate increase of groundnut cake flour in the blends. Similarly, taste of the loaves suffered with increase in the proportion of the cake flour in the blends as a result of the presence of sand and dust present in the cake flour. Taking an over-all view of these studies, the maximum mixable limit of the cake flour should not exceed five per cent.

Summary

The optimum proportions of sweet potato and groundnut cake flours which can be advantageously mixed with wheat *atta* for making *chapatis* were found to be 30 and 5 per cent respectively, while for the preparation of the loaves (leavened), the appropriate limit is five per cent, in respect of both the supplementary flours. The amount of sweet potato flour in the mixed *chapatis* can well be stretched to 50 per cent in time of emergency, but the taste of *chapatis* in this case would be characteristic of the boiled sweet potatoes. The flour made from scalded tubers was undoubtedly of a superior quality than that prepared from unscalded tubers.

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A PRELIMINARY NOTE ON THE ESSENTIAL OIL BEARING PLANTS OF KASHMIR

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In continuation of our previous work on this subject [Chopra, Handa and Kapoor] some more aromatic plants growing in a state of nature in Kashmir valley were collected in the course of our botanical excursions. Seeds of some of the exotic aromatic plants were also procured from foreign countries through the courtesy of UNESCO and raised in our nurseries for investigation. The results of preliminary work on all these plants are given below :

1. *Arctium lappa* Linn. (Great Burdock)

This is a tall, course, erect, biennial herb which grows in abundance in Kashmir at an altitude of 7,000 ft. above sea level. The plant was recognized in the B.P.C. 1934 and is much used in the treatment of gout. In the U. S. A. a tincture prepared from the seeds is used in psoriasis, acne and prurigo. The roots are exported in fairly large quantities from Italy, Germany and Belgium to the U. S. A. and the drug is collected both from wild and cultivated sources in Europe.

The roots of the plant growing wild were collected from the Gulmarg range and these were steam distilled. The oil obtained had the following characteristics :

Yield of the oil	0·75 per cent
Specific gravity	1·1315 at 15°C.
Refractive index	1·415 at 20°C.

2. *Chenopodium ambrosioides* var. anthelminticum Gray (Wormseed)

This plant is the source of commercial wormseed oil which is used as a vermifuge to expel roundworms and hook-worms. It is indigenous to Southern and Central America and does not grow in India. Its seeds were procured through the courtesy of UNESCO from Turkey and were raised in the Drug nurseries at Srinagar (5,000 ft.) and Yarikah (7,000 ft.) for experimental cultivation. Under favourable soil and agricultural conditions the seeds sown in May germinated in about three weeks time and were transplanted, when they obtained a height of about 6 in. The germination and the growth of plants was better at Srinagar (5,000) than at Yarikah (7,000) where the growth appeared stunted. The fresh herb was harvested from both the places when the plants were in fruiting condition in September and October. The specimens collected from the two nurseries were steam distilled. The results obtained are compared with the characteristics of the foreign oil.* (Table I)

*The British Pharmaceutical Codex 1949.
The British Pharmacopoeia 1948.

The method of Cocking and Hymas as given in B.P. 1948 has been adopted for the estimation of ascaridole in the oil.

TABLE I

Results of steam-distilled oils compared to foreign oil

Characteristics	Yarikah Nursery	Srinagar Nursery	Foreign oil
Yield from dry herb	1·16 per cent	0·82 per cent	0·6 to 1 per cent
Specific gravity at 15°C.	0·8913	0·877	0·956 to 0·977
Refractive index at 20°C	1·794	1·457	1·474 to 1·479
Percentage of ascaridole	8·5	7·2	Not less than 65

3. *Chenopodium botrys* LINN.

It is an erect, herb with glandular-pubescent branches and cymes spreading and recurved.

It is distributed in India from Kashmir to Sikkim at an altitude from 4,000 to 10,000 ft. In Kashmir it is found growing commonly in fields at 7,000 ft. It has a pleasant and very aromatic smell. The whole herb growing as a weed was collected from the Drug Farm, Yarikah, for steam distillation of the oil. The results are given below.

Yield of the oil.	0.18 per cent
Refractive index at 20°C.	1·4895

4. *Anethum graveolens* LINN. (DILL) (SYN. *Peucedanum graveolens* BENTH. AND HOOK. *f.*)

This plant is indigenous to South Europe and is cultivated in England, Germany, Rumania and the Mediterranean region. The essential oil (dill oil) or its emulsion in water is considered to be an aromatic carminative specially useful in the flatulence of children. This plant does not grow here but another species of *Anethum* known as *Anethum sowa* Roxb. (Indian dill, sowa) is cultivated in India. For trial cultivation, the seeds of *Anethum graveolens* were procured from Prof. W. O. James of Oxford University and were sown in the Yarikah Drug Farm (7,000 ft.) in a well prepared bed in May 1951. The seeds reacted favourably to its new environments, germinated successfully and a small crop of fruit was obtained in the following October and November. The dry fruit on steam distillation gave a pale-yellow oil with the following properties and these are compared with the foreign oil. (Table II)

TABLE II

Comparison of dry fruit oil with foreign oil

Item	Dry fruit oil	Foreign oil
Yield of the oil	2·39 per cent	2 to 4 per cent
Specific gravity	0·876 at 15°C.	0·895 to 0·910
Refractive index	1·472 at 20°C	1·481 to 1·492
Percentage of carvone	45·9	Not less than 43 per cent not more than 63 per cent

The method given in the B. P. 1948 was employed for the estimation of carvone in the oil.

5. *Senecio chrysanthemoides* DC

This plant is found distributed in the temperate to alpine Himalayas from Kashmir and is very common in the open and covered forest blanks at 8,000 to 11,000 ft. It flowers in the months of July and August. The plant when in flowering stage emits a characteristic fragrance but the whole dry plant on steam distillation gave only traces of oil.

6. *Tanecetum vulgare* LINN. (TANSY)

It is a perennial aromatic herb indigenous to Europe and extensively cultivated there [Kraemer, 1916]. The leaves are large and pinnately divided. The flowers are yellow the heads being in terminal corymbs.

In Europe the Plant yields from 0·1 to 0·3 per cent of volatile oil containing thujone, borneol, camphor and resins. The oil is used as a flavouring agent. The plant does not grow in India, nor is it reported by Hooker [1879].

Tanecetum vulgare has been found growing as an escape near the Drug Farm, Yarikah (Kashmir). It may have been introduced as an ornamental plant but there is no record when it was introduced. It is a hardy plant and can be easily extended for cultivation on an extensive scale.

The whole flowering plants were collected for the study of its essential oil and the results are recorded below and compared with the American oil [Gildemiester and Hoffman, 1922].

TABLE III

Comparison of Tanecetum vulgare *oil with American oil*

Characteristics	Tanecetum oil	American oil
Yield of the oil	0·6 per cent	0·2 to 3 per cent
Specific gravity at 15°C.	0·939	0·925 to 0·935
Refractive index at 20°C.	1·4615	1·457 to 1·459

7. *Ocimum kilimandschricum* GUERKE

The camphor yielding tree *Kaurus camphora* does not grow in India but it is raised successfully in India. The yield of camphor was, however, considerably low to give any promise of economic exploitation. During the war time a plant *Ocimum kilimandscharicum* Guerke was introduced in the plains of India. The essential oil from this contains a good percentage of camphor. The seeds of this plant were received through the courtesy of President, Forest Research Institute, Dehra Dun for experimental cultivation in Jammu. The seeds were sown broadcast in a few beds in March. The irrigation and weeding and thinning was done when necessary, and it germinated in about three weeks' time. The whole plant was harvested in the flowering stage in August and after drying in shade was steam distilled. The results are given below :

Yield of the oil	4·7 per cent
Specific gravity at 15°C.	0·878
Refractive index at 20°C.	1·4606

Although the yield of the oil compared favourably with that grown in Dehra Dun, it was found that no camphor separated on chilling. Total distillate of 4 to 5 per cent and camphor to the extent of about three per cent on zero moisture leaves has been reported from plants grown at the Forest Reserach Institute, Dehra Dun.

8. *Morina longifolia* Wall.

It is a tall spinous herb bearing pink flowers and distributed in the temperate and alpine Himalayas from 9,000 to 14,000 ft. above sea level. In Kashmir the plant grows wild at Khilanmarg, in Sindh valley and Pir Pinjal ranges. The roots of some other species of *Morina* have been reported to be used by Budhists in Lahoul as an incense [Watt, 1892]. The plants possess strong aromatic properties. The whole plant was collected for steam distillation and the following results were obtained :

Yield of the oil	0·34 per cent
Specific gravity at 15°C.	0·9525
Refractive index at 20°C.	1·4775

9. *Mentha piperita* Linn. (*podina*)

In a previous communication (Chopra, *et al.*) results of *Mentha piperita* raised in Baramulla were reported. The plant has now been raised in Yarikah (7,000 ft.) by rooted suckers.

The plant reacted favourably to this place as well but the growth remained stunted. The whole plant was harvested in October. A pale yellow oil was obtained which had the following characteristics :

Yield of the oil	0·5 per cent
Specific gravity at 15°C.	0·9232
Refractive index at 20° C.	1·4614

The oil was chilled in ice but no menthol separated. Attempts are being made to procure seeds of some better variety of *Mentha piperita* which gives oil containing a good percentage of menthol.

10. *Sium latijugum* C. B. Clarke

This plant is widely distributed in Kashmir and Baltisthan from 5,000 to 9,000 ft. In Kashmir it is commonly found in the Jhelum and Sindh valleys as a weed and imparts strong fragrance to its surroundings.

Whole flowering plants were collected from Yarikah 7,000 ft. for steam distillation of its volatile oil. The results are given below :

Yield of the oil	0·946 per cent
Specific gravity at 0°C.	0·1877
Refractive index at 20°C.	1·4894

SUMMARY

Ten more essential oil bearing plants both those growing in a state of nature and exotics introduced for cultivation have been investigated. The yield and some of the physical properties of oils obtained from them have been studied and compared with those obtained in foreign countries.

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STUDIES ON THE VIABILITY OF IMMATURE WEED SEEDS

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WHILE working on the viability of weed seeds belonging to the family *Gramineæ* and *Compositæ* at the various stages of maturity, Gill [1938] came to the conclusion that they are capable of germination long before they seem to be fully ripe. In India, where eradication of weeds by cultural methods is practically the only solution known to the cultivators and where it is a common practice to allow these cut weeds to remain in the field for a long time, observations along similar lines are expected to be of great significance.

Experimental

The following *rabi* weeds of the local surroundings were selected for study :

Anagallis arvensis L.; *Argemone mexicana* L.; *Asphodelus tenuifolius* Cav; *Chenopodium album* L.; *Chenopodium murale* L.; *Lathyrus aphaca* L.; *Melilotus alba* Lamk.; *Melilotus indica* All.; *Oxalis corniculata* L.; *Solanum nigrum* L.; *Spergula arvensis* L.; *Vicia hirsuta* Gray.

For each species, seeds at different stages of development were collected from a number of flowers opening on the same day. In plants with solitary or large flowers, the individual flowers were tagged on the day of their opening. Where small flowers, individually distinguishable without the aid of a hand lens, were clustered in an inflorescence, the following procedure was adopted :

Tops of the inflorescences with young buds were cut off and the open flowers and the developing pods below were removed allowing only such buds as were going to open the next day to remain. Any flower bud that failed to open on that day was again carefully separated. Pods were collected at an interval of five days and dried in the sun. The seeds obtained from them were stored in desiccators till required for the germination test. In *Chenopodium album* and *C. murale* the flowers were extremely minute and the seeds at different stages of development were obtained according to the technique adopted by Gill [1938].

One hundred seeds of each species at each stage of development were selected at random after nearly seven month's storage and were placed on moist filter papers in petri dishes for germination. In a few cases, where the total number of seeds collected was less, the entire lot was used for the test. These dishes were placed inside the laboratory and watered at regular intervals. The experiment was started on 1 October, 1950 and terminated on 30 November of the same year. The germinated seeds were counted daily and removed.

Data obtained for the total germination percentage of the various weed seeds at different stages of maturity are presented in the Tables I and II.

TABLE I

Germination percentage of weed seeds collected at various intervals

Plants	Date of harvest	Germination percentage of seeds collected after (days)										
		5	10	15	20	25	30	35	40	45	50	55
A. arvensis L.	28-2-50	0	0	4	4	4	..	..	..	..	..	..
A. mexicana L.	17-1-50	0	0	0	0	0	0	20	53	64	59	100
A. tenuifolius CAC.	29-1-50	0	0	24	56	68	44	38	23	23	6	..
L. aphaca L.	27-2-50	0	0	75	88	100	100	100	..	..	..	..
M. alba Lamk.	28-1-50	0	0	0	0	0	0	4	..	..	..	..
M. indica All.	29-1-50	0	0	0	12	12	14	16	..	..	..	..
O. corniculata L.	14-3-50	0	0	0	0	..	..	..	..	..	..	..
S. nigrum L.	16-1-50	0	0	20	22	24	28	84	96	94	94	84
S. arvensis L.	14-3-50	4	8	12	..	..	..	..	..	..	..	..
V. hirsuta Gray	28-2-50	0	0	10	64	85	98	..	..	..	..	..

TABLE II

Germination percentage of weed seeds collected at various stages of development

Plants	Germination percentage				
	Stage I	Stage II	Stage III	Stage IV	Stage V
C. album L.	0	0	8	4	0
C. murale L.	28	28	28	20	4

A perusal of Tables I and II indicates that out of the 12 species of weeds worked upon, the seeds of *Oxalis corniculata* both mature and immature fail to germinate. This most probably is due to storage. Barton Wright [1937] reports that the seeds of *Oxalis* 'germinate as soon as they leave the capsule and quickly die if exposed to a dry atmosphere'. Of the rest with the exception of *Melilotus alba* which has extremely poor germination, the immature seeds of each and every species show various degrees of viability. In *Melilotus indica* and *Anagallis arvensis*, the germination percentages of mature and immature seeds do not differ much, while in *Argemone mexicana*, *Solanum nigrum*, *Lathyrus aphaca* and *Vicia hirsuta*, there is progressive increase in the total germination percentage as the seeds become more and more mature.

Asphodelus tenuifolius presents a very interesting case. Here the seeds collected only 15 days after the opening of the flowers, show considerable viability (24 per cent) which reaches the maximum after another 10 days. Seeds more mature than this, however, show a decrease in the percentage of germination. In fully mature seeds, there is as low a germination percentage as six. Similar lowering in the percentage of germination with an increase in maturity of seeds is also noticed in *Chenopodium album* and *murale*. This might be due to a progressive increase in the thickness of the seed coat. It is highly interesting to record that the mature seeds of dominant *ravi* weeds of the cultivated fields of this region like *Melilotus*, *Chenopodium* and *Asphodelus* show a very high degree of dormancy in the first year.

Summary

Viability of the seeds of several common *rabi* weeds of the local surroundings, collected at various intervals after the opening of their flowers, was found out.

It was observed that the immature seeds of most of these weeds are capable of germination. In *Melilotus indica* and *Anagallis arvensis*, there is hardly any difference in the germination percentage of mature and immature seeds. In *Argemone mexicana*, *Lathyrus aphaca*, *Solanum nigrum* and *Vicia hirsuta*, there is a progressive increase in the total germination percentage as their seeds become more and more mature. The immature seeds of *Asphodelus tenuifolius* germinate better than fully mature seeds.

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REVIEWS

MANGO STUDIES

(*Published by Florida Mango Forum. United States of America, 1952, pp. 156, Price $4*)

THE book is a compilation of papers presented at the Florida Mango Forum over the past 10 years on the culture, marketing and preservation of mango fruit.

Information on the various aspects of mango growing in Florida is embodied in this book in 33 articles, each contributed by a different author and is based upon his experience and specialised knowledge of the subject. The subject matter, therefore, covers a wide and varied field and is written mainly from the view point of its practicability and usefulness to prospective growers of this distinctive, promising and potentially valuable tropical fruit.

The chapters on introduced and originated varieties in America show the extent to which the Americans have advanced in respect of this fruit although its home is in South East Asia. Most of the varieties have been introduced from India besides other Asiatic countries and have been multiplied by selection. Haden variety got introduced into Florida in the seventies. The first mango tree, a Mulgoba, was introduced from India in 1889. The varieties of origin in Florida have been described and illustrated. Also included is an appendix giving a comprehensive list of varieties introduced. (S.S.).

FIELD CROPS

By Howard C. Rather and Carter M. Harrison

(*Published by McGraw-Hill Book Co. Inc., New York, 1951, pp. 446, Price $ 5.50*)

THIS is the revised, second edition of the useful book originally written by Dean H. C. Rather. It is stated in the preface to the first edition that it was intended to provide a broad basis for college students of agronomy or for those whose speciality may be in other or related fields of agriculture. The book deals with such topics as classification of farm crops, soil conservation and management, tillage and cultivation besides a detailed account of a number of crop plants which includes the description of the methods of growing and harvesting these crops and the uses of the grain and agricultural products. A good deal of attention is given to forage crops, hay-making, silage, pastures and pasture management. However, there is hardly any information on the field crops grown in other countries.

References to literature are provided, and also questions and problems in various forms, at the end of each Chapter (B.P.P.).

YEARBOOK OF FOREST PRODUCTS STATISTICS, 1951

(Published by the F. A. O. of the United Nations, Rome, Italy, 1951, pp. 181, Price Rs. 12-8)

THIS is the fifth Yearbook of Forest Products Statistics prepared by F. A. O.'s Forestry Division and contains new information for 1950 and revised data for 1949 for more than 100 countries. The statistics include data for output of wood and production, trade and consumption of various types of processed wood, wood pulp and its products. Mexico, Afghanistan, South Africa, Argentine and China are the main areas for which no information is available. For East European countries and the U. S. S. R. only estimates made by the F. A. O. have been given.

The main producers of wood and wood products in the world are United States and Canada 36 per cent, U.S.S.R. 32 per cent, and Europe 18 per cent. United States and the Europe are the main exporters as well as the main consumers. It is interesting to note that there has been a tremendous increase in the production of ply wood and wood pulp since the war. Production of news-print on the other hand, had actually shrunk since the war began and reached the pre-war level only in 1949. The publication contains an important table showing forest areas of the world, as these areas represent the potential forest wealth. U. S. S. R. leads in this respect, followed by Northern and Central America, while the forest area in Asia is just half of that of the U. S. S. R. It is interesting to note that Burma has a slightly larger forest area than India. The publication does not contain any tables on forest products other than wood such as bamboo, rattan, gums, resins, etc. while these represent only a small fraction of the total forest wealth, statistics of production for bamboo and rattan are of special economic interest to countries in South East Asia and should be included if possible. One point that needs attention is the building up of series of comparable data. A footnote at one place in the text states that increase in the estimate of output is due to new information that has become available. It is desirable, if possible, to show such additional information separately and keep the original series in tact so that a study of real changes in output might become possible.

The present publication represents one of the tangible results of the activities of the F. A. O. in making available to Statisticians, Economists and others for the first time, comprehensive reference material in agricultural and allied fields. (V.G.P.)

YEARBOOK OF FOOD AND AGRICULTURE STATISTICS, 1951

VOLUME V, PART II, TRADE

(Published by the F.A.O. of the United Nations, Rome, Italy, 1952, pp. 236, Price Rs. 17-8)

THE present publication brings up-to-date trade statistics in food and other agricultural commodities. It contains new figures for 1950 and the latest revised data for the years 1947, 1948 and 1949, compared with the pre-war (1934-38) averages. The commodities have been grouped into sections dealing with cereals, sugar, potatoes, fruits, oil seeds, fibres, live-stock and live-stock products, etc. The

tables include export and import data for each country for various individual items under the different sections. At the end there are notes explaining what physical quantities the data under each commodity stand for and how they are assembled for different countries. The material presented in this volume appears to have a remarkably complete geographical coverage, the striking exceptions being Russia and certain countries in Eastern Europe. For these some data on the prewar estimates and a few post-war figures from non-official sources are alone available.

With the present emphasis on food, the tables present some interesting comparisons. Table I-B on cereals, for example, shows that North and South America are principal surplus areas of the world and it is thus a case of the new world feeding the old. Incidentally, it is not clear why in this table the bread grains and food grains do not add up exactly, in several cases, to the figures given under total cereals. Wheat and rice are the most important food crops of the world. For wheat Asia is an importer, the principal importing countries being India and Japan. Before the last war, India had a net export of this cereal to its credit, but the position has altered since then and India is now importing large quantities of wheat. In regard to rice, India has always been an importer, although it is interesting to note that rice import are apparently declining. Indonesia, Japan and Malaya are the other rice importing countries in Asia. On the other hand, Burma has been, in the past, the largest exporter of rice not only in Asia but perhaps in the whole of the world. Burmese exports have, however, declined in recent years due to dislocation of production in the country. Indo-China, another important exporter, has suffered a similar set-back, and Thailand is today the principal exporter of rice in Asia.

The present publication providing, as it does, a global picture of trade in food and other agricultural commodities is one of the benefits accruing from the activities of the Food and Agricultural Organisation. It is useful as a reference not only to Government statisticians and students of Economics, but also to the trade and industry interested in the world supply and movement of various agricultural commodities. (V.G.P.)

THE INJURIOUS INSECTS OF THE BRITISH COMMONWEALTH

By J. W. Evans

(*Published by the Commonwealth Institute of Entomology, London, 1952, pp., 242, Price £ 1.10s.*)

THIS book is intended to provide a source of reference on the more injurious insects of the British Commonwealth with the exception of the British Isles, India and Pakistan. The latter countries have been excluded because their problem are considered to be so numerous that every one of them requires a separate book for itself. The other main reason of the author for excluding these countries, that they have comparatively few *imported* pests of considerable significance does not appear to be well founded. However, the countries covered include such far distant continents such as Africa, Australia, New Zealand, West Indies, etc. and therefore many of the pests described are common to several other countries particularly India.

Whereas insects of medical and veterinary importance have been dealt with on country-basis, those of agricultural crops and forestry are described in a systematic manner under various insect groups. The latter arrangement has an advantage since if arranged on crop basis, it would have meant a large amount of duplication as many pests have numerous crop hosts, and many crops are common to several countries. General problems such as those of Plant Quarantine, Principles of insect control, Lines of Research are described in separate sections and a whole chapter is devoted to Weed Control by Insects.

Most of the information given about various pests is summarized from the abstracts published on the subject in the ' Review of Applied Entomology ' during the last 30 years or so. It is indeed a very useful compilation and therefore the handbook will fulfil adequately the objectives with which it has been written. The author deserves congratulations in every respect. Of course it is meant for technical field workers. General cultivators, planters and laymen will require accounts of various injurious insects in a style, indicating concretely the advice which they might follow in controlling the various pests.

Very few research entomologists will share the view referred to by the author that in the future the control of insect pests will be a matter for Chemists and Engineers. Though the most common method of insect control is and is likely to remain by dusting and spraying insecticides, such a view does not represent proper appreciations of the problems involved in pest control. For example in the sphere of medicine, chemists help in evolving drugs, but the exact nature of drug required is indicated by the research worker in human physiology and pathology. Similarly in the case of insect pests, the main work will always have to be done by insect biologists, physiologists and ecologists, who will solve the various problems with the help of chemists and engineers. Of course such help is indispensable, under research problems the author has rightly warned that because an insect is recorded from different parts of the world under one name, it should not be always assumed that it has in all respects the same organisms and further that the recorded facts about its biology and physiology as applicable in the countries where they are studied are applicable in all other countries.

The reason of the author for omitting an account of the storage pests and of parasites of world-wide distribution that they are cosmopolitan and have little regional significance, does not appear to be strong as a chapter or section to each of these two subjects could have been usefully devoted, as in the case of insect vectors of viruses. Similarly ' special problems ' such as Plant Quarantine, Principles of Insect Control and Research needs require much more space than about ten pages devoted by the author. Obviously this was due to some limits laid down in regard to the size of the handbook.

The author's suggestion that senior entomologists should prepare regional handbooks on pests found in their territories is commendable. The information given in this book will serve as nuclii for comprehensive handbooks for various regions or countries.

The get-up and printing of the handbook is good. It has on front page the portrait of Sir Guy A. K. Marshall, which is very becoming as no other single entomologist has stimulated so much interest in economic entomology in the Commonwealth countries, as Sir Guy. (H.S.P.)

DISEASES OF VEGETABLE CROPS

By John Charles Walker

(*Published by McGraw-Hill Book Co., Inc. New York, 1952, pp. ix and 529, Price £1, 10s.*)

PLANT pathologists will receive with interest the book on 'Diseases of Vegetable Crops' by John Charles Walker. The attempt of the author to bring together available information on the nature and control of most diseases of important vegetable crops has no doubt been successful. The book has been divided into eleven chapters and altogether about 411 diseases caused by fungi, bacteria and viruses have been described. The more important diseases numbering about 100 have received greater attention. Symptoms and history of the diseases as well as disease cycle have been carefully discussed. Essential information on control measures of the diseases has also been provided. Along with each disease, bibliography is provided to facilitate reference to original work.

It has been stated that a mosaic disease of egg-plant described by Raychaudhuri in India is transmitted by means of aphids, whereas he claims to have transmitted the disease by the agency of *Embosca devastans.*

It is difficult to make a manual of this type satisfactory from all aspects. Nevertheless, this manual written by one of the most eminent plant pathologists would be of immense value both to the students and teachers, as also to research workers for ready reference. (R.S.V.)

LATERITE AND LATERITIC SOILS

By J. A. Prescott and R. L. Pendleton

(*Published by Commonwealth Agricultural Bureaux, Farnham Royal, Bucks, England, 1952, pp. 51, Price 6s. 0d.*)

THIS is a welcome addition to our knowledge of Laterites and associated soils. A comparison of the present communication with the former one issued in 1932 on the same subject brings out into prominence the efforts of the present authors to present a complete account of the publications on this subject. The authors have very wisely omitted the agricultural bias in the earlier publication and rightly emphasised the genetic concepts. The subject is treated under the main heads : 1. Field characteristics of Laterite, 2. Geographical distribution of Laterite, 3. The Nature of Laterite, 4. The Origin of Laterite and 5. Lateritic soils. The authors have carefully drawn from the original publications and quoted the relevant information. They used the term laterite in the original sense used by Buchanan, viz.

an indurated clay, most suitable for building material. The derivation of the word is from Latin—*later*; a brick. The geographical distribution of laterites in different countries is illustrated by appropriate maps. The chemical and mineralogical characters already display the general uniformity in their composition and their origin from acid and basic rocks, indicating the uniformity of the process responsible for their genesis. In discussing the theories of weathering, laterite as a soil horizon, the authors indicate their mind in favour of Campbell's view. Campbell separated the process of rock decomposition in tropics into alteration and weathering, the former taking place in the zone of permanent saturation and the latter in the zone of intermediate saturation. In summarising the contemporary ideas on the mobility of iron and alumina, the complicated and diverse mechanisms are clearly brought out.

The position of red earths, red loams and other groups of soils in relation to laterites is not clear. It is a happy augury that the authors devoted a section on lateritic soils and their fertility.

In conclusion the authors make bold in advocating that 'the use of the term laterite as the name for a Great Soil Group may now well be dropped', as ferruginous materials, 'especially but not exclusively in fossil form, might be found in several of the zonal soils but their presence might be regarded as accidental at the categorical level of the Great Soil Groups'.

This publication is very likely to create fresh interest on the study of Laterites and generally on tropical soil forming processes. (S.P.R.)

SAND AND WATER CULTURE METHODS USED IN THE STUDY OF PLANT NUTRITION

By E. J. Hewitt

(*Published by the Commonwealth Bureau of Horticulture and Plantation Crops, East Malling, Maidstone Kent, England, pp. 243, Price 42 S. or $6·25*)

THE study of plant nutrition, involving as it does the recognition of the great importance of occurrence in plants of certain elements in exceedingly small is beset with considerable difficulty in respect of interpretation of the mutual interaction of a large number of nutrients as well as of experimental technique. With a view to overcoming the inherent difficulty of experimenting with such a heterogeneous culture medium as the soil, plant physiologists devised nearly a century ago the technique of water and sand cultures. A number of variations of this technique developed in different laboratories during the course of last 50 years and the monograph under review is intended to serve as a source of information on this subject. Plant Physiologists and horticulturists engaged in the investigation of nutritional problems should feel grateful to Dr Hewitt for providing them with such a useful reference guide. The practical details of these techniques are lucidly described in detail and illustrated with a number of clear diagrams. This monograph should be in the possession of every laboratory where the subject of plant nutrition is being taught and/or investigated. (R.D.A.)

JUTE SUBSTITUTE FIBRES

By A. E. HAARER

(Published by Wheatland Journals Ltd., 1952, pp. 183)

FOR quite a long time India had the monopoly in the production and supply of jute, the most important and the cheapest of all packing materials. During the World War II conditions so developed that supplies of raw jute to other consuming countries were cut off. Countries in other parts of the world were long looking for various substitutes for sackings and hessians made of jute. The course of events during the last war compelled them to find out jute substitutes not only to meet their immediate requirements, but to become self-sufficient in the matter of the supply of a cheap packing material. Various kinds of substitutes for jute sackings like paper bags, cotton bags, etc. were tried, but none of them were found quite suitable. So the countries which normally consumed jute and jute goods from India, felt very much the need for either producing jute or a fibre very much similar to jute. Experiments in the large scale production of jute have failed in most of the countries, but quite a large amount of success was achieved in producing some other fibres like Mesta or Bimli jute (*Hibiscus cannabinus* Linn.), Roselle (*Hibiscus sabdariffa* Linn.) and Congo jute or Aramina fibre (*Urena lobata* Linn.).

In India all these three fibre plants, discussed in detail in this book, have been very well known since long past. The first two namely, *Hibiscus cannabinus* Linn. and *Hibiscus sabdariffa* Linn. have also been in cultivation since remote past; but since true jute (*Corchorus capsularis* Linn. and *Corchorus olitorius* Linn.) proved to be the cheapest and most suitable fibre for sacking and wrapping material, it occupied the most prominent position in the fibre economy of the world. This favourable position with regard to the supply of raw jute remained undisturbed till the partition of India ending in the creation of Pakistan.

In this book the author has dealt with these three important jute substitute fibres in great detail. All aspects of the cultivation and production of the fibre namely, selection and breeding, cultural and spacing requirements, diseases and pests, harvesting and retting have been elaborately discussed. Morphological and cytological characters of each of the fibre plants have also been dealt with separately. The author has brought together a valuable mass of information collected from various publications on the subject as also from what he has gained by his long experience in tropical agriculture in Africa.

The author has laid much stress, as it should be, on the possibilities of mechanisation of cultivation and extraction of fibre from the fibre plants. This important aspect of the problem of fibre production has been very ably dealt with.

It is inevitable that the reviewer should find himself somewhat critical in a subject in which he has first-hand knowledge. A few errors have been detected here and there. On page 3, 5-6 lines from the top, it has been described, ' It (Bimlipatam jute) forms most of the inner part of the bark or cortex, etc. ' The inner part of the bark is not the cortex. The small amount of fibre forming the outermost

Instructions to Authors

Articles intended for *The Indian Journal of Agricultural Science* should be accompanied by short popular abstracts of about 330 words each.

In the case of botanical and zoological names the International Rules of Botanical Nomenclature and the International Rules of Zoological Nomenclature should be followed.

Reference to literature, arranged alphabetically according to authors' names, should be placed at the end of the article, the various references to each author being arranged chronologically. Each reference should contain the name of the author (with initials), the year of publication, title of the article, the abbreviated title of the publication, volume and page. In the text the reference should be indicated by the author's name, followed by the year of publication enclosed in brackets ; when the author's name occurs in the text, the year of publication only need be given in brackets. If the reference is made to several articles published by one author in a single year these should be numbered in sequence and the number quoted after year both in the text and the collected references.

If a paper has not been seen in original it is safe to state 'original not seen'. Sources of information should be specifically acknowledged.

As the *format* of the journal has been standardized, the size adopted being crown quarto (about 7½in.×9⅝ in. cut), no text figure, when printed should exceed 4½ in.×5 in. Figures for plates should be so planned as to fill a crown quarto page, the maximum space available for figures being 5¼ in.×8 in. exclusive of that for letter press printing.

Copies of detailed instructions can be had from the Secretary, Indian Council of Agricultural Research, New Delhi.